

ESSAYS IN ENVIRONMENTAL  
AND  
PUBLIC ECONOMICS

by

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## DISSERTATION ABSTRACT

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Doctor of Philosophy

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Title: Essays in Environmental and Public Economics

Benefit-cost analysis of environmental policies typically focuses on benefits to human health and well-being. When it comes to humans' WTP for improvements in the quality of life for other species, however, the evidence is limited. We argue that the other-species morbidity-reduction component of WTP should be calculated net of any "outrage" component associated with the cause of the harm. This net WTP is likely to be correlated with the premium that people are willing to pay for chicken products from birds for which the quality of life has been enhanced by improved animal welfare measures. This paper uses a conjoint choice stated preference survey to reveal the nature of systematic heterogeneity in preferences for "humanely raised" versus "conventionally raised" chicken. We also use latent class analysis to distinguish between two classes of people – those who are willing to pay a premium for humanely raised chicken and those who are not.

Proposition 21 on California’s 2010 ballot concerned an \$18 annual surcharge on vehicles to support state parks. Prop 21 failed, implying 25% of these parks risk closure. Voting patterns at the Census tract level depend on gross price, incomes, age profiles, political ideology, environmental preferences, the availability of local substitutes, and park salience. We simulate counterfactual scenarios under which Prop 21 might have passed and use county-level hold-out samples to illustrate the predictive ability of our model.

The California Air Resources Board is slowly phasing out perchloroethylene as the main input in dry cleaning operations in the state. Exploiting differential implementation of this regulation between SCAQMD (South Coast Air Quality Management District) and the rest of the state, we examine the effect of this regulation on the propensity for dry cleaning businesses to exit the industry. We find that regulation has encouraged early exit from the industry in some cases. We also find that regulation decreased ambient concentrations of perchloroethylene in the atmosphere.

This dissertation contains both published and unpublished co-authored material. It also contains an appendix for chapter II as a supplemental file.

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## CHAPTER I

### INTRODUCTION

The common threads throughout this dissertation are both environmental economic and political economic in nature. The second chapter uses techniques common to environmental economics to estimate WTP values for other species' wellbeing. The third chapter uses voting results to estimate demand for public parks funding. The fourth chapter examines the effects of an environmental regulation on an industry comprise of mostly small businesses, using the dry-cleaning industry in California as an example.

The second chapter of this dissertation is entitled "WTP for other species' wellbeing". Using a conjoint choice state preference survey, we find that some portions of the population possess a positive WTP premium for humanely raised meat, which we argue is likely to be positively correlated with concern for the wellbeing of other animals. Using latent class analysis, we also find what appear to be two distinct classes of people: those with a positive WTP premium and those who do not have a positive WTP premium.

The third chapter of this dissertation is titled "Payment Vehicles for Public Goods: Evidence from California State Parks". Proposition 21 on California's 2010 ballot concerned an \$18 annual surcharge on vehicles to support state parks. Owners of vehicles registered in California would then be excused from paying park user fees. Prop 21 failed, resulting in 25% of these parks being scheduled for closure. Voting patterns at the Census tract level depend on gross price (the average per-household number of vehicles), incomes, age profiles, political ideology, environmental preferences, the availability of local substitutes, and park salience. We simulate counterfactual scenarios under which Prop 21 might have passed and

use county-level hold-out samples to illustrate the predictive ability of our model.

The title of the final chapter is “The Effects of Environmental Regulation on Dry-cleaning Firm Exits”. In compliance with the Clean Air Act, the state of California has implemented a phase down of the chemical perchloroethylene (PCE), which is the most widely used technology in dry-cleaning operations. PCE has been shown to be carcinogenic. We examine the determinants of dry cleaners’ decisions to exit the industry or continue business as usual, as well as if the regulations were effective in reducing ambient concentrations of PCE. We use data from the National Establishment Time Series (NETS) database for business characteristics, data from the SCAQMD, and data from the Census and ACS for neighborhood characteristics, as well as emissions data from the California Air Resources Board. We do not find evidence that the regulations adversely affected dry cleaners, although we do find that the regulation reduced the ambient concentration of PCE in the atmosphere.

Chapters II, III, and IV contain material co-authored with Trudy Ann Cameron.

## CHAPTER II

### WTP FOR OTHER SPECIES' WELL-BEING

#### Introduction

Benefit-cost analysis of environmental policies typically pays a great deal of attention to benefits in the form of protection or enhancement of the health and well-being of humans. Researchers have therefore produced an abundance of evidence about willingness to pay (WTP) for reductions in human mortality risks. There is also considerable evidence regarding WTP for reductions in human morbidity risks, and other quality-of-life benefits such as improved visibility or reduced noise. For environmental risks to *other species*, researchers have also had some success in measuring people's WTP to increase the abundance of an endangered species, for example, or to preserve biodiversity (see Richardson and Loomis (2009) for a meta-analysis). However, these values are mostly for reductions in *mortality* risks for other species. There is considerably less evidence concerning WTP for reductions in *morbidity* risks for other species, or to protect other aspects of their quality of life.

It is important for economists to consider human values for other-species morbidity risk reductions because environmental economists are often criticized for their anthropocentric view of the value of environmental quality. Morbidity risk reductions for other species have standing in conventional benefit-cost analyses only if humans are willing to pay something for these reductions. Accordingly, this study seeks to isolate additional evidence of human WTP for quality-of-life improvements for other species.

Of course, the view one takes of environmental valuation efforts depends upon one's philosophical framework. Many people take a deontological view. They feel

that the protection of other species is a categorical imperative and that the well-being of other species has intrinsic value, independent of the relationship between these species and humans. Other observers, however, subscribe to a teleological view, where other species have utilitarian value to the extent that their well-being matters (ultimately) to the well-being of humans. As economists, we take the more pragmatic teleological view. We steer away from normative ethical issues and address the positive question of people's willingness to pay for improvements in the well-being of other species. Our work is motivated by recognition that benefits stemming from the well-being of non-human species should be represented more frequently in environmental benefit-cost analyses.

This component of environmental benefits is rarely included in benefit-cost analyses because there has been relatively little research available. For example, consider a benefit-cost analysis of a prospective environmental regulation that would reduce the chance of a coastal oil spill, for example. It would be inappropriate to attempt to transfer, to all potentially injured birds, a measure of WTP to prevent the death of a brown pelican. Brown pelicans are atypical, since they have been recently de-listed as an endangered species. Likewise, suppose we were considering an estimate of the benefits of a regulation aimed at preventing non-fatal rodenticide poisoning of common barn owls. Such a benefits estimate should not rely upon measures of WTP to protect endangered spotted owls, whose survival has been linked to the preservation of old-growth forests. If we want to isolate a component of WTP that pertains solely to the well-being of the animal itself, while it is still alive, we need a context that is not confounded by endangered species status or symbolic values. We need estimates of WTP limited to the well-being of the living animal, not conflated with other values such as WTP associated only with reductions in mortality. WTP to improve the quality-of-life of farm animals would seem to be the ideal measure of



this component of value, since these animals tend to be numerous and ordinary. This WTP, if anything, would serve as a lower bound for WTP to improve the well-being of a more charismatic species. Furthermore, the reduction of mortality risks is not an issue, in this case, because most of these animals are raised specifically to be killed for food.

Human WTP on behalf of other humans, of course, requires consideration of the nature of the altruism involved and the prospect for double counting.<sup>1</sup> However, double-counting is not a concern when animal well-being is involved because the animals themselves are not part of the franchise for benefit-cost analysis and animals' WTP values on their own behalf will not otherwise be counted.

A challenge in this line of research is that there are relatively few familiar market contexts in which consumers need to consider their willingness to incur the costs necessary to provide clean air or water or an otherwise safe and healthy environment for both wild and domesticated animals. In this paper, we assume that consumers' WTP for these types of benefits will be correlated with their willingness to pay higher supermarket prices so that farm animals raised for food can be provided with a better quality of life.

In this study, we use survey data to measure consumers' incremental willingness to pay for "free range" and "humanely raised" poultry versus "conventionally raised" poultry, and demonstrate numerous statistically significant dimensions of heterogeneity in preferences for animal welfare improvements. We find that the per-pound premium willingly paid for the humanely raised product varies inversely with household size and with the respondent's rating of his or her own

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<sup>1</sup>If altruism is non-paternalistic, in the sense that people care only about other people's levels of utility, then aggregate WTP may be merely the sum of individual WTP amounts. If altruism is paternalistic, so that people care about other people's levels of consumption of specific goods, then there is sometimes room to include people's WTP on behalf of others as well as on their own behalf.

ideological conservatism. In contrast, this premium varies directly with educational attainment and the extent to which the respondent is concerned about antibiotics, growth hormones, and genetic engineering. It also varies directly with the extent to which the respondent believes that the humanely raised product is healthier for humans and with the extent to which he or she believes that humane standards for farm animal care actually improve the well-being of these animals.

Additionally, we explore a model where we identify two distinct latent preference classes. Both classes are sensitive to prices, but one preference class derives positive utility from free-range and humanely raised products, and the other is clearly unwilling to pay any premium at all for free-range or humanely raised products.

This paper is organized as follows. Section 2 outlines the rationale for our approach as a function of the institutional context and then briefly reviews the scope of the related literature and differentiates our inquiry from other existing work. Section 3 describes our data and Section 4 lays out our model and the corresponding estimating specification. Section 5 presents our results and some discussion, and Section 6 concludes.

## **Institutional Context and Broader Literature**

### *A Missing but Potential Market*

Our study is based upon a consumer survey that involves so-called “stated preferences,” elicited via sets of conjoint choice experiments, to determine which types of consumers are more or less willing to pay for improved farm animal welfare, as well as the magnitude of this WTP.<sup>2</sup> A stated preference survey is necessary to

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<sup>2</sup>Methods such as these are widely used in the marketing and transportation choice literatures, as well as in environmental and health economics contexts. They are sometimes the only available

assess WTP for humane treatment of farm animals because there is no uniform set of criteria permitting an unambiguous definition of “humanely raised” meats. Thus the product in question is not yet well-defined. U.S. Federal law currently requires only that animals raised for meat be made unconscious before being slaughtered, because farm animals are exempt from other federal animal welfare laws (US Code: Humane Methods for Livestock Slaughter, Title 7, chapter 8). Conventional methods of raising animals for food have proven cost-effective for farmers, and these practices often include maximizing the density of animals, using growth-inducing hormones, and using feed that includes animal by-products. Raising animals in high densities forces many farms to physically alter the animals by, for example, cutting tails, toes, and beaks so that they cannot injure one another. It also forces producers to regularly administer antibiotics to control disease.

While “humanely raised” products are not widely available, many grocery stores do carry meat products labeled “free-range” which fetch a substantial price premium—in some instances as much as four times the price of conventionally raised meats. However, a portion of the premium that consumers are willing to pay for free-range meats has been attributed to concerns for human health and safety as well as ethical concerns – both for the environment and for the welfare of the animals themselves. Unfortunately, a “free-range” label has essentially no legal meaning or standard certifying body, so this designation does not correspond to a well-defined product either. Nevertheless, existing price premia for free-range meats suggest that there may also be a substantial unmet demand for some form of certification ensuring that the animal in question has been raised humanely.

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method for measuring prospective demand for new products or non-market demands for public goods.

Of course, it is an empirical challenge to attribute a WTP premium for free-range or humanely raised meats solely to the consumer’s interest in animal welfare. In the choice scenarios presented in our survey, we are careful to stipulate that “The store offers three brands of chicken breasts that look the same. The color, size and fat content of each brand are very similar. The only visible difference is that one brand is marked ‘Conventional,’ one brand is marked ‘Free-range,’ and the third brand is marked ‘Humane.’ ” But consumers may believe that the products are likely to differ in other ways that are not visible. For example, they may believe that free-range or humanely raised products are more (or less) healthy for human consumption, that they are more tender (or tougher), or that they are more or less tasty than conventionally raised products. It seemed improbable that all consumers would accept that the three types of products would be identical on all of these dimensions, so we have been careful to elicit each respondent’s subjective perceptions on these three quality dimensions: healthiness, tenderness, and tastiness. This permits us to control for these perceptions and, if necessary, to simulate counterfactually what consumers would have been willing to pay had they perceived that all three products were identical on these dimensions as well.<sup>3</sup>

### *Relevant Literature*

Farm animal welfare has been a topic of growing interest in recent years in the agricultural economics literature, but we seek via this study to increase the attention of environmental and ecological economists to analogous concerns about wildlife, including how these concerns might factor into benefit-cost analysis of environmental policies.

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<sup>3</sup>A set of five Appendices accompanies this dissertation. Appendix A contains a few additional institutional details. These appendices are available as a supplemental file to the dissertation.

**Well-being of other species.**—Relatively little work has yet been published that emphasizes other-species morbidity reductions as a potentially important source of concomitant social benefits from environmental regulations, and none appears to have been formally economic in nature. However, Blumstein (2010) describes how forest management practices can create noise, frighten animals, and lead to heightened glucocorticoid levels in wildlife, along with disruption to their communication and reproduction. Mathews (2010) describes how agricultural activity can affect wild animal welfare and conservation, arguing in particular that the suffering of pest animals has traditionally been undervalued. Paquet and Darimont (2010) confirm our premise by noting that “the notion that animal welfare applies to wildlife has escaped many animal welfarists and conservationists.” These authors adopt a deontological perspective and focus on the example of the grey wolf and how habitat destruction and impoverishment causes trauma, suffering, and death for this species. We argue that these considerations are potentially important in formal benefit-cost analyses as well.

**Economic animal welfare studies.**—This literature seems to begin with Bennett (1997), followed by Bennett (1998), Bennett et al. (2002), Bennett and Blaney (2002), and Bennett and Blaney (2003). This early work relies most heavily upon contingent valuation methods. Glass et al. (2005) find that a significant subset of the population appears to be unwilling to pay anything at all for the welfare of pigs (and this heterogeneity is fully consistent with the findings of the present paper). Schnettler et al. (2009) find that consumers care both about humane treatment and the geographic origin of their beef. Taylor and Signal (2009) find that certain demographic characteristics, such as age, income, and gender, are important in determining WTP for humane practices for food animals. This last paper is perhaps closest to our own work, although a number of other papers also use animal welfare

questions as a vehicle for an examination of important methodological issues; these include Chilton et al. (2006), Carlsson et al. (2007) and Bateman et al. (2008).

**Confounding attributes.**—Other potentially confounding product attributes are considered in some studies. Carlucci et al. (2009) and Napolitano et al. (2008) have used an auction procedure to study yogurt products. Along with animal welfare as a product attribute, they include other competing attributes such as sensory properties of the product. These are akin to the attributes of perceived healthiness, tastiness, and tenderness employed in our own study, as discussed above. Similarly, Nilsson et al. (2006) consider broader features like food safety, environmental degradation, and animal welfare as competing attributes which affect WTP for a product.

**Biodiversity.**—There are several papers which seek to estimate WTP to preserve biodiversity or to retain numbers of individuals belonging to an endangered species. For example, in selected recent work, Han and Lee (2008) use both stated and revealed preference methods to assess WTP values for preservation of Manchurian black bears in South Korea. Eiswerth and van Kooten (2009) use a model of optimal management policy to determine the economically optimal stock of the greater sage grouse in Nevada. Meta-analytic methods are used by Richardson and Loomis (2009) to reveal that WTP for preservation of endangered fauna has increased over time. It is likely that some types of people will care only about *numbers* of live animals in these contexts, but some people may also be concerned about the quality-of-life, including non-fatal illnesses (morbidity), among other species. Others will place little or no value on either the lives or the well-being of other species. We seek to identify systematic patterns in the distribution, across the population, of these different patterns of concern. This knowledge will help define the different constituencies in terms of support for proposed policies or regulations.

**Demand for food attributes.**—A few other papers investigate consumer WTP for animal-based food products as a function of the attributes of that food. There is a considerable literature that focuses on WTP for organic foods or consumer preferences regarding genetically modified organisms (GMOs). However, this literature focuses on the impact on the environment of different farming methods, or to the uncertain risks to humans and other species stemming from alterations to the global gene pool, food security, and human health implications. Examples of this research include Larue et al. (2004), Farina and Almeida (2003), and Grunert and Bech-Larsen (2005). Further, Balcombe et al. (2009) find that people prefer bread made with wheat that has been grown with reduced levels of pesticides, while Bougherara and Combris (2009) find that it is difficult to tease out private and public components of WTP for environmentally friendly products, even in a controlled experiment.

**Sustainable agriculture.**—Our paper is also related, although less closely, to the literature on sustainable agriculture, where the interaction between food production and ecosystems is a common theme. While the emphasis is more commonly upon endangered species, the well-being of some type of wild species is also implicit in the concerns about natural capital which are noted in most cases. Some notable papers in this area of research include Goodland (1997), Johnston et al. (2001), Rigby et al. (2001), Wilson and Tisdell (2001), and Van Passel et al. (2007)

**Attitudes about animal welfare.**—A number of authors in other social science disciplines have surveyed consumers to learn about their attitudes concerning animal welfare. For example, Tonsor et al. (2009) examined animal welfare considerations for swine. Frewer et al. (2005) have looked at attitudes about livestock welfare in general, while Schröder and McEachern (2004) considered value conflicts for consumers in their purchasing decisions. Harper and Makatouni (2002) find that

consumers typically have trouble separating the quality of meat from the welfare of the animal. Some studies merely ask whether the consumer would be willing to pay any positive premium over conventional products for a humanely raised alternative (for example, Martelli (2009) and Ellis et al. (2009)). Recently, Nocella et al. (2010) found that among certain EU countries, trust between consumer and producer had a positive influence on consumer WTP for certified animal friendly products.

**Methodological issues.**—Several papers focus on methodological issues but employ an animal welfare question as the vehicle for an empirical illustration. Choice experiments were used by Carlsson et al. (2007) to derive WTP in the context of animal welfare considerations for cattle and broilers. Liljenstolpe (2008) explores a random parameters logit model in this context. Bateman et al. (2008) employ animal welfare related survey data, but the main focus of their analysis is methodological. As always, stated preference methods have received the expected scrutiny. Chilton et al. (2006) use a farm animal welfare application to raise questions about the reliability of stated preference methods because they do not find strong convergence between WTP based methods and matching methods for identical populations.

**Voting data.**—There is some revealed preference data that can convey attitudes about improvements to animal welfare in the form of voting behavior on a handful of propositions (referenda) in a few U.S. states. Vederas (2006) considers a 2002 Florida ballot proposal to limit farming practices that were deemed to be cruel to pigs. To explain county-level voting data, religion was a statistically and economically relevant variable, but political preferences and socio-economic factors are determined to be of greater importance than religious affiliation.

**Other approaches.**—Frank (2008) asks whether there is a type of Kuznets Curve for animal welfare. Thiermann and Babcock (2005) consider globalization, interest in animal welfare worldwide, and the prospect for international standards



on animal welfare. Other voices raise familiar questions from the non-economic community, for example Mann (2005), who argues that the design of “ethological” farm programs should be based on “broad public discussions as described by deliberation theorists rather than willingness-to-pay studies.

## Survey Data

Our stated preference survey is presented to respondents as data collection to support background research concerning the viability of a potential new meat-certifying and labeling program. Randomized baseline prices are quoted for a “conventional” product, and randomized price premia for “free-range” and “humanely raised” products are used to generate the prices quoted for these other products.

Our conjoint choice stated preference survey was designed and fielded in 2006. To obtain a relatively random sample of the adult population of one county in the U.S. at relatively low cost, we collected responses from the jury pool at the county courthouse in our own jurisdiction. The jury pool population consists of adults selected at random from lists of registered voters and licensed drivers residing in the county.<sup>4</sup>

In our survey, respondents were presented with choice scenarios where they were asked to consider whether to purchase a given quantity and type of chicken breasts, assuming that they were on a typical food shopping trip. We analyze two such choices for each individual in our sample. Each choice involves three

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<sup>4</sup>Survey booklets were hand-delivered to the jury assembly room. The survey was announced with a neutral description of its topic and the fact that it was the basis for an academic research project at the local university. A sealed “ballot box” was provided for the return of completed surveys, and additional surveys were left near the box with a placard containing the same explanation that had been delivered verbally. Survey completion was not monitored. The completed surveys were collected later. The result is a sample of convenience, and there is no way to measure response rates accurately. The sample is similar to the general population of the U.S. on many observable dimensions other than race, but there is no way to assess the possibility of systematic selection on unobservables.

packages of chicken breasts of a specified common weight (between 1.5 to 3 pounds) and three different types (conventional, free-range, or humanely raised), as well as a no-purchase option. Since certified humanely raised products were not widely available at the time of our survey, respondents clearly had to base their expectations about their potential demand for these products on the descriptions of humane farming practices provided in our survey and extrapolation from the characteristics of various free-range or organic products more commonly available at the time. Few respondents would have had any actual experience with certified humanely raised products. Online Appendix B describes our survey design and the resulting data in greater detail. Table 1 provides summary statistics for the variables used in our estimating specification.<sup>5</sup>

One concern with stated-preference surveys is that some respondents may tend to overstate their willingness to pay. Possible reasons for this include an attempt to please the researcher or the hope that by overstating WTP, the good or service in question will be provided and the respondent’s option to buy the good in the future will be preserved. To limit this behavior, respondents were informed that a charitable organization funded by other concerned individuals would be established to certify meat as “humanely raised.” However, this would happen only if it was determined that a large enough share of the general population was willing to pay the necessary price premium in the hypothetical shopping scenarios presented in the survey. Respondents were further reminded that it was important for this organization to receive realistic information about potential demand. Should the organization go ahead with the meat-certifying program, they would not be able to

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<sup>5</sup>Since several of the attitudinal variables employ a seven-point rating scale, Figure B1 in Online Appendix B also provides histograms for the complete distributions of each of these ratings.

fund other worthy causes that the respondent might also care about. This framing of the choice task represents an effort to make the respondent’s choices “consequential.”

Another concern with survey data is that respondents may attempt to second-guess the motivation of the research team in asking these questions. To minimize any perception of bias in our survey, we were careful to present both the pros and the cons of the proposed programs. We also posed a direct query about researcher bias in our debriefing questions: “Think about the way the information in this survey was presented. How important do you think it is to this research team for people to buy humanely raised meat products?” Perceptions ran the gamut from “1 = Not at all important” to “4 = Neutral” to “7 = Extremely important.” We were pleased to see that the modal value was 4, but more people gave high ratings than low ratings. Of course, it is difficult to avoid completely the impression that we care about humane treatment of farm animals since respondents will impute this to a certain extent from the fact that we are conducting the study at all. Fortunately, use of this variable as a potential shifter of estimated preference parameters yielded no statistically significant effects.<sup>6</sup>

## Model and Estimating Specification

There are two standard ways to use stated preference methods to derive WTP measures for non-market or pre-test-market goods. One technique, sometimes called “stated behavior,” describes a possible market to respondents and asks how many units of the product in question they would choose to purchase per period, say per month or per year. These data on quantities demanded per period can then be modeled as functions of income and prices, based on the microeconomic

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<sup>6</sup>Best-practice protocols for the conduct of stated preference survey were observed to the fullest extent permitted by the resources available for this study. Many standard conventions for mail surveys are relevant in this context. See Dillman (2000), for example.

construct known as a Marshallian demand curve. The other common technique, employed here, involves asking respondents about single choice occasions, where a given selection would be made under a particular set of conditions. When the choice scenario involves multiple alternatives and multiple varying attributes for each alternative, this method is commonly called “conjoint choice” analysis. If the choice is merely to buy a specified product (vote for a public good) or not, this method is often called a “contingent valuation”. Consumer choices are then explained using a so-called discrete-choice “random utility” econometric model where the parameters to be estimated are interpreted as marginal utilities associated with net income and with the quantities of each attribute. Given these estimated marginal utilities, it is straightforward to solve for the implied Marshallian demands. The conjoint choice approach asks only that respondents contemplate specific choice occasions, rather than ponder their cumulative purchases across many choice occasions. Conjoint choice tasks are thus viewed by many researchers to be easier for survey respondents.

We will develop our model in the context of Choice Scenario #1, an example of which is depicted in Figure 1. Respondents encountered this first choice set on the sixth page of the survey instrument. Indirect utility for each alternative in the choice set is considered to be a function of (1) the individual’s income remaining after the purchase decision and (2) the quantity of the product purchased. The “no-purchase” alternative, of course, involves no cost. The simple equations below describe utility  $U_i^j$  as a function only of the cost of the package,  $c_i^j$ , and quantity of product contained in the package,  $q_i^j$ , described to subject  $i$  for each alternative  $j = C, F, H, N$  (where C = conventionally raised, F = free-range, H = humanely raised, and N = no purchase). For the moment, we ignore the differences in utility that might stem from different attributes of each type of meat, so the indirect utility

function involves only two parameters:  $\beta_Y$ , the marginal utility of net income, and  $\beta$ , the marginal utility of a pound of chicken:

$$\begin{aligned} U_i^j &= \beta_Y(Y_i - c_i^j) + \beta q_i^j + \eta_i^j, & j = C, F, H \\ U_i^N &= \beta_Y(Y_i) + \eta_i^N \end{aligned}$$

Net indirect utilities for the model, calculated relative to the “no-purchase” or “status-quo” option, are then:

$$\Delta U_i^j = (U_i^j - U_i^N) = \beta_Y(-c_i^j) + \beta q_i^j + (\eta_i^j - \eta_i^N) = \Delta V_i^j + \epsilon_i^j \quad j = C, F, H \quad (\text{II.1})$$

McFadden’s conditional logit choice model (Greene (2008), p. 846-847) assumes that subjects will prefer the alternative that conveys the highest attainable indirect utility in the choice set. The stochastic structure of the conditional logit model (i.e. the distributions typically assumed for  $\epsilon_i^C$ ,  $\epsilon_i^F$ , and  $\epsilon_i^H$ ) leads to choice probabilities that can be expressed in terms of the observable portions of utility for product types  $j = C, F, H$  and the no-purchase alternative,  $N$ :

$$\begin{aligned} P_i^j &= \frac{\exp(V_i^j - V_i^N)}{\exp(V_i^C - V_i^N) + \exp(V_i^F - V_i^N) + \exp(V_i^H - V_i^N) + 1} \\ P_i^N &= \frac{1}{\exp(V_i^C - V_i^N) + \exp(V_i^F - V_i^N) + \exp(V_i^H - V_i^N) + 1} \end{aligned}$$

To estimate the main unknown utility parameters  $\beta_Y$  (the marginal indirect utility for income) and  $\beta$  (the marginal utility per generic pound of chicken, for example) the following log-likelihood function is maximized:

$$L = \prod_{i=1}^n [P_i^C]^{C_i} [P_i^F]^{F_i} [P_i^H]^{H_i} [P_i^N]^{N_i} \quad (\text{II.2})$$

where  $C_i = 1$  if person  $i$  chooses the conventionally raised product and  $C_i = 0$  otherwise; similarly for  $F_i$ ,  $H_i$  and  $N_i$ .

Once the parameters of the indirect utility function are estimated, it is possible to solve for the individual's maximum WTP for a package of chicken of a specified weight. This maximum WTP is the price at which the individual would be just indifferent between paying for and consuming the product, and not paying for the product, thereby forgoing consumption. Indifference implies identical utility between these two options, or a zero utility *difference*, so we set the estimated indirect utility difference relative to the numeraire alternative equal to zero for  $j = C, F, H$  and solve for the package cost,  $c_i^{j*}$ , that satisfies the equality  $0 = \Delta V_i^j = \beta_Y(-c_i^{j*}) + \beta q_i^j + \epsilon_i^j$ . This implies:

$$\beta_Y(c_i^{j*}) = \beta q_i^j + \epsilon_i^j \quad \Rightarrow \quad c_i^{j*} = \frac{\beta q_i^j + \epsilon_i^j}{\beta_Y} = \left( \frac{\beta}{\beta_Y} \right) q_i^j + \left( \frac{\epsilon_i^j}{\beta_Y} \right) \quad (\text{II.3})$$

where  $\epsilon_i^j = (\eta_i^j - \eta_i^N)$ . This amount,  $c_i^{j*}$ , calculated from the maximum likelihood estimates of the two utility parameters, is interpreted as the maximum WTP for  $q_i^j$ . We note that this can be expected to match the market equilibrium price for chicken breasts only for the marginal consumer. For inframarginal consumers, this WTP can be expected to exceed the market equilibrium price.

The error term in equation (II.3),  $\epsilon_i^j/\beta_Y$ , is symmetric around zero, so its expected value can be assumed to be zero. The expected value of maximum WTP for a package of generic chicken is thus  $\beta/\beta_Y$  times the quantity (pounds) of chicken in the package,  $q_i^j$ . In other words, maximum WTP *per pound* of chicken is given by the ratio of the marginal utility per pound of chicken,  $\beta$ , to the marginal utility per dollar of income,  $\beta_Y$ .

In this study, however, our main research question concerns differences across types of chicken in this WTP amount. Thus we allow the marginal utility per pound of chicken to vary systematically with the type of chicken (conventional, free-range or humanely raised.) The baseline marginal utility,  $\beta_C$ , will be assigned to conventionally raised chicken, but the marginal utility per pound of chicken will be a systematic varying parameter that shifts by  $\delta_F$  if the chicken is free-range, and by  $\delta_H$  if the chicken is humanely raised. Thus the indirect utility-differences for  $j = C, F, H$  that drive the choices will be generalized via appropriate interaction terms:

$$\begin{aligned}\Delta U_i^j &= \beta_Y(-c_i^j) + (\beta_C + \delta_F F_i^j + \delta_H H_i^j)q_i^j + \epsilon_i^j \\ &= \beta_Y(-c_i^j) + \beta_C q_i^j + \delta_F F_i^j q_i^j + \delta_H H_i^j q_i^j + \epsilon_i^j\end{aligned}\quad (\text{II.4})$$

where  $F_i^j = H_i^j = 0$  if the product is conventional,  $F_i^j = 1$  if the product is free-range (0 otherwise), and  $H_i^j = 1$  if the product is humanely raised (0 otherwise). Solving for the maximum WTP for a package of chicken yields

$$\text{Max WTP} = c_i^{j*} = \frac{(\beta_C + \delta_F F_i^j + \delta_H H_i^j)q_i^j}{\beta_Y} + \frac{\epsilon_i^j}{\beta_Y} \quad (\text{II.5})$$

A statistical test of the hypothesis that respondents are willing to pay no more for free-range meats than for conventional meats is a test of  $\delta_F = 0$ . Likewise, a test of the hypothesis that respondents are willing to pay no more for humanely raised meats is a test of  $\delta_H = 0$ . If these parameters prove to be positive and statistically significantly different from zero, then a point estimate of the per-pound *premium* willingly paid for the free-range product is  $\delta_F/\beta_Y$  and a point estimate of the per-pound *premium* willingly paid for the humanely raised product is  $\delta_H/\beta_Y$ .

To accommodate systematic heterogeneity in preferences across our sample, as a function of individual characteristics and perceptions, we next generalize *each* scalar preference parameter in equation (II.4) to be a systematic varying parameter. We introduce potentially different types and numbers of shift variables for each marginal utility, including variables  $Z_i$  for the marginal utility of income, and variables  $X_i^C$ ,  $X_i^F$ , and  $X_i^H$  for the marginal utility of the conventionally raised product and the *differentials* in marginal utility for the free-range and humanely raised products. Each vector of variables also includes a constant term. The resulting more-general utility difference can be written to emphasize these systematically varying marginal utilities, or to establish the specific second- and third-order interaction terms required to estimate the four parameter vectors:

$$\begin{aligned}\Delta U_i^j &= (\beta_Y Z_i) (-c_i^j) + \left[ (\beta_C X_i^C) + (\delta_F X_i^F) F_i^j + (\delta_H X_i^H) H_i^j \right] q_i^j \\ &= \beta_Y (-Z_i c_i^j) + \left[ \beta_C (X_i^C q_i^j) + \delta_F (X_i^F F_i^j q_i^j) + \delta_H (X_i^H H_i^j q_i^j) \right] \quad (\text{II.6})\end{aligned}$$

If we assume linearity as in equation (6), this generalization means that the fitted TWTP for a package of chicken (of weight  $q_i^j$  pounds) is given by

$$TWTP_i^j = \left( \frac{1}{\beta_Y Z_i} \right) \left[ (\beta_C X_i^C) + (\beta_F X_i^F) F_i^j + (\beta_H X_i^H) H_i^j \right] q_i^j \quad (\text{II.7})$$

Then the per-pound premium for the free-range and humanely raised product will be simply the partial derivatives with respect to the type and the quantity:

$$\frac{\partial^2 TWTP_i^j}{\partial F_i \partial q_i^j} = \frac{\delta_F X_i^F}{\beta_Y Z_i}, \quad \frac{\partial^2 TWTP_i^j}{\partial H_i \partial q_i^j} = \frac{\delta_H X_i^H}{\beta_Y Z_i} \quad (\text{II.8})$$

These ratios are nonlinear functions of the asymptotically joint normal maximum likelihood parameter estimates, so we use simulation methods to build up a sampling



distribution of values for these key derivatives with respect to each statistically significant shift variable. Ultimately, we are interested in the further derivatives of these premia with respect to the variables in  $Z_i$  and  $X_i^F$ .

## Results and Discussion

Table 2 presents parameter estimates for the simplest possible homogeneous-preferences specification that still permits an estimate of the premium for the humanely raised product. The marginal utilities are assumed to be common across all individuals and the only distinction made is between the three different types of products. Calculated simply as  $\delta_H/\beta_Y$ , these estimates suggest a WTP premium for the humanely raised product of about \$0.58 per pound.

However, we are particularly interested in evidence of systematic heterogeneity in these WTP amounts. If we understand the patterns in WTP for humanely raised products, we will understand better the types of constituencies which will be especially important when it comes to benefit-cost analysis of environmental regulations (or other public policies) where one type of benefit is prevention of non-fatal harm to other species. Table 3 provides the maximum likelihood parameter estimates for our preferred (parsimonious) model with heterogeneous preferences. This is again one single model, although the estimates in the middle section of the table are arranged in three columns to highlight the base marginal utility for the conventional product in the first column and the differentials in marginal utility for the free-range and humanely raised products in the next two columns, with each of the rows showing the dimensions of statistically significant heterogeneity in this base marginal utility and the two differentials.<sup>7</sup>

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<sup>7</sup>As usual, this specification is a result of extensive exploration across a larger array of potential sources of heterogeneity. The basic homogenous-preferences specification in Table 2 demonstrates that there is a statistically significant utility differential for humanely raised products. All of the

The first interesting result in Table 3 is the effect of gender on the parameter which gives the marginal utility of income. Females display a marginal utility of income that is greater than that for males, which tends on average to decrease their willingness to pay for anything (a fairly typical result in consumer choice analysis). A tendency for women to be less willing to pay for any of these products, including any premium for the humanely raised products, contrasts with the attitudinal study by Prickett et al. (2010) where support for animal welfare measures is particularly strong for females. It seems their higher marginal utilities of income dominate their greater sentiments for animal welfare in an economic analysis.<sup>8,9</sup>

In this paper, however, we are particularly interested in the third column in the body of Table 3. The per-pound WTP premium for the humanely raised product is given by  $\delta_H$  divided by the marginal utility of income (which is  $\beta_{Y0}$  for males and  $(\beta_{Y0} + \beta_{Y1})$  for females). Since  $\delta_H$  varies according to the values of several respondent characteristics and attitudes, so will the WTP premium for humanely raised products. Table 3 thus illustrates that WTP varies *inversely* with household size and with the respondent's rating of his or her own degree of ideological

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other specifications we have considered are generalizations of that simple model. The surviving covariates in Table 3 are retained because they tend to be robustly statistically significant across alternative specifications. Note that the coefficient on the negative of total price, in a model that is linear in net income, gives the marginal utility of income.

<sup>8</sup>Although one usually expects declining marginal utilities of income, the estimated marginal utility of income in our sample does not seem to change as income increases. We find this result despite having introduced income into the model in a variety of different ways in our exploratory analyses.

<sup>9</sup>An anonymous referee asked about the preferences of respondents who reported that they did not know the prices of the conventional or free-range products they consume. We provide online Appendix E with some additional results. Table E-1 reports results for two models which use indicators for respondents who buy conventional or free-range products but do not know the typical price of the product. These models reveal evidence consistent with these individuals having a lower marginal utility of income (implying a less binding budget constraint and therefore a higher WTP).

conservatism.<sup>10</sup> In contrast, the WTP premium varies *directly* with educational attainment and the extent to which the respondent is concerned with farming practices that involve antibiotics, growth hormones, and genetic engineering<sup>11</sup>. It also varies *directly* with the extent to which the respondent believes that the humanely raised product is healthier for humans<sup>12</sup> and the extent to which he or she believes that humane standards actually improve the well-being of animals.<sup>13</sup> While we collected numerous other attitudinal variables, sufficient orthogonality to permit identification of separate effects was present only for these few variables. To the extent that these variables are collinear with other attitudes, of course, these included variables (used alone) will pick up some of these other effects.

Interestingly, in an alternative specification not reported here, we find no statistically significant lump-sum effect on fitted indirect utility associated solely with the product being conventional, free range, or humanely raised. Product type affects the marginal utility *per pound*, not just the overall utility level per package. Thus, the WTP premium for the humanely raised product is expected not to be associated merely with the act of purchasing this type of product, but with the quantity actually purchased. This makes it more likely that the premium reflects concern about other-species well-being, rather than just potential “warm glow” from buying the more socially desirable product. Furthermore, a simple distinction between the

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<sup>10</sup>Survey question D.12: In terms of politics, how do you consider yourself? (1 = Extremely liberal, ..., 4 = Moderate, ..., 7 = Extremely conservative)

<sup>11</sup>Survey question C.3: In choosing among different brands of chicken breasts, to what extent were you thinking about antibiotics, growth hormones, or genetic engineering and how these might affect chicken products? (1 = Not at all, ..., 7 = A lot)

<sup>12</sup>Survey question A.6: Do you think that humanely raised meats might be more or less healthy for people to eat than conventional meats? (1 = Much less health than conventional meats, ..., 4 = Equally healthy, ..., 7 = Much more healthy than conventional meats)

<sup>13</sup>Survey question A.4: How much do you think these requirements would actually improve the wellbeing of livestock and poultry raised on certified farms? (1 = Not at all, ..., 7 = a lot)

no-purchase alternative and any of the three products also makes no statistically significant difference in expected utility, despite the fact that many conjoint choice studies with a no-purchase alternative find a significant “status quo” effect.<sup>14</sup>

It is not surprising that people are willing to pay a higher premium for the humanely raised product if they believe that it is healthier for humans. We expected that we might also see systematic effects on the WTP premium when respondents believed that the humanely raised product was more desirable in other ways as well, for example if it was expected to be tastier or more tender than the conventional product. Opinions relating to the overall quality of humanely raised versus conventional products tend to be somewhat positively correlated, so it proves difficult to include all of them in a single specification and to achieve statistically significant coefficients on each interaction term. Since the perceived “healthiness” attribute seems to dominate, our preferred specification includes only that control for these desirable attributes beyond simply the animal welfare dimension. Of course, we acknowledge that the coefficient on the “healthiness” will certainly pick up some of the explanatory power that would otherwise be attributed to tastiness or tenderness, had there been more independent variation in the three types of perceptions.

The quantitative WTP implications of these parameter estimates are conveyed in Table 4. This table describes distributions for the calculated value of the per-pound WTP premium for the “humanely raised” product, based upon 1000 random draws from the assumed joint normal distribution of the maximum likelihood parameters estimates.<sup>15</sup> It appears that female respondents are willing to pay a per-pound premium for the humanely raised product that is about \$0.19 lower for each extra

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<sup>14</sup>Other alternative specifications are discussed in online Appendix C.

<sup>15</sup>A full table of results, including those for the “free-range” alternative, is included in online Appendix D.

person in their household. Likewise, the more ideologically conservative this female respondent rates herself to be, the lower is the expected WTP premium for the humanely raised product. Each rating point on the attitudinal scales for healthiness and improvement to animal well-being increases the expected female WTP premium for the humanely raised product by about \$0.25 per pound. Concerns about antibiotics, growth hormones, and genetic engineering have the greatest effects, with each rating point increasing the premium by an average of \$0.30 per pound for females. All of the corresponding simulated WTP premiums for male respondents are greater, of course, because the estimated marginal utility of income (which appears in the denominator in each case) is smaller for males.

However, we are interested in simulating individual WTP for animal welfare improvements alone; that is, WTP for reductions in morbidity for the species in question, *net* of any WTP for the related human health impacts resulting from consumption of these animals. For this purpose, it seems appropriate to impose the following counterfactual condition: healthiness set at 4 = “equally healthy.” However, there remains the question of the appropriate values to simulate for the other attitudinal variables: “H. (humane standard) improves well-being” and “antibiotic concerns.” We relegate this exploration to the online Appendices accompanying this paper, but we will summarize the results here. Online Appendix Table D-2 begins by reporting the size of the premium for the humanely raised product, evaluated first at the marginal means of the data, across individuals, for each of the variables that contribute to heterogeneity in these values. This premium is approximately \$0.70 per pound, with a 95% interval that between \$0.33 and \$1.02 per pound.<sup>16</sup>

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<sup>16</sup>Subsequent rows of online Appendix Table D-2 display simulations for specified departures from the overall sample mean values of the relevant variables, and asterisks highlight cases where the fitted premium is bounded away from zero.

In considering which of the WTP simulation results in Table D2 might be most appropriate, we are inclined to allow respondents to retain their own subjective opinions about the extent of any ill treatment that farm animals receive under conventional farming methods. At the same time, we want to net out any component of WTP that is explicitly due to the selfish perception that the humanely raised product would be better for humans to consume (as opposed to being better for the farm animal). Unfortunately, it is somewhat difficult to ensure that we have completely achieved this goal. For the concerns about antibiotics, growth hormones, and genetic engineering, we posed the question specifically in terms of “how these might affect chicken *products* [emphasis added]” as opposed to the birds themselves. However, we cannot rule out that respondents might reasonably have been worried about the latter. If farming practices are not healthy for humans who consume these products, then they are likely to be unhealthy for the animals in question as well.

With these considerations in mind, we believe that the best estimate of the humanely raised premium may be the WTP calculated otherwise at the means of the data, but with the “healthy” and “antibiotic concerns” ratings set equal to their *neutral* values (i.e. 4). Fortunately, the mean value of the latter rating is 3.86, so the distinction between the sample mean and the simulated value is minimal. This implies that our best estimate of average household WTP for average subjective improvements in animal welfare is about \$0.34 per pound, but the 95% interval includes everything from -\$0.23 to +\$0.82. For greater perceived improvements in animal well-being, however, it is clear that people are willing to pay substantially more for the humanely raised product.

### *Latent Class models*

When heterogeneity in preferences is introduced by allowing individual utility parameters to vary systematically with observable characteristics and elicited attitudes of the consumer, there are, in principle, as many unique different sets of preferences as there are unique combinations of these characteristics and attitudes. Sometimes, however, it is helpful to learn whether there might be some smaller number of roughly distinct preference types. These can be construed as distinct “market segments,” as opposed to the near-continuum of consumer types identified in models like that in Table 3. A latent class model may be appropriate in this case.

Latent class models are based on the supposition that some small finite number of different preference functions can be used to explain most people’s choices. If membership in a preference class could be treated as deterministic, indicator variables for each preference class could simply be used to shift each preference parameter in the model. In a latent class model, however, membership in preference classes is unobserved, and must be inferred by the researcher. A two-class latent class model typically involves a class separation sub-model where respondent characteristics are used to predict preference class membership. Then, conditional on (stochastic) class membership, a distinct set of preference parameters is estimated for each class.

We have explored a number of latent class specifications to determine how many distinct preference types might be discerned in our data. It turns out that at most two distinct preference classes are identifiable, as described in Table 5.<sup>17</sup>

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<sup>17</sup>We programmed our latent class estimator in Matlab. Note that the numbering of the preference classes as Class 1 and Class 2 is completely arbitrary. We also note that we tried a variety of three-class models, but none could be coaxed to convergence. Point estimates may be construed to suggest the possibility of a third preference class minimally distinct from Class 2 in Table 5, but there appears to be insufficient information in the data to identify this third preference class.

In the top portion of Table 5, it can be seen that individuals with both Class 1 and Class 2 preferences are sensitive to prices. Individuals with Class 1 preferences, however, derive statistically significantly greater utility from either the free-range or the humanely raised product compared to the conventional product. In contrast, individuals with Class 2 preferences derive statistically significantly *less* utility from either the free-range or the humanely raised product than from the conventional product.

The lower portion of Table 5 reveals that it is somewhat difficult to pin down a good separation index for these two classes, but if anything Class 2 preferences are *more* likely for respondents who have larger households (and potentially for individuals who view themselves as ideologically more conservative); Class 2 preferences are *less* likely for people who believe that humane standards will make more of an improvement in animal welfare (and potentially for people who report being concerned about antibiotics, growth hormones, or genetic engineering and how these might affect chicken products).<sup>18</sup>

While all of the preference coefficients for Class 2 are individually statistically significant, the implied premiums willingly paid per pound for the free-range or humanely raised products for this Class are negative. This occurs despite the fact that the free-range or humanely raised options were never priced *lower* than the conventional option, so the best we can do is to interpret these coefficients as implying a definite zero incremental willingness to pay for the humanely raised product for this market segment.

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<sup>18</sup>Gender appears to have no discernible effect on class membership; having at least a bachelor's degree *may* reduce the chance of being in Class 2 (in some specifications, for a slightly different subsample of the data), as may the opinion that the humanely raised product is healthier. However, inclusion of the "H. (humanely raised product) healthiness" variable causes the coefficient on the "antibiotic concerns" variable to become even less significant. It is worth noting that these perceptions (healthiness and antibiotic concerns) are somewhat correlated. These correlations are discussed in online Appendix C.



Thus the latent class model seems to be telling us that there is one market segment that views free-range and humanely raised products favorably and another that cares nothing for them. Had the separation equation been more precisely estimated, the latent class model might be something we could pursue. Of course, there may be other discernible classes in this market if one had sufficient data to be able to discriminate between them. Given the tenuousness of the separating equation, however, our preferred specification involves the systematically varying parameters in Table 3.

### *Caveats and suggestions for further research*

In this study, we chose to elicit from each individual their perceived levels for several attributes of humanely raised products. For example, we asked whether they thought that humanely raised standards would improve animal well-being (“H. improves well-being”). Ideally, one would like to be able to “treat” each respondent with exogenously defined information about humane standards for farm animals and to have them completely accept this information. Then it might be possible to contemplate an exogenous change in this information to derive answers to the question of “How would WTP change when animal welfare is changed?” We might have attempted to *assert* to respondents (rather than eliciting their subjective ratings about) the extent of animal welfare improvements under certification, the relative healthiness of humanely raised products versus conventional products, and how much worry is appropriate concerning antibiotics, growth hormones, and genetic engineering. These exogenous product design “attributes” could then have been added to the minimal list of product attributes in the current choice sets. Or, we could have asked respondents (explicitly) to assume *no* difference in healthiness, and *no* human health effects from consumption of conventional products that are not

also present in the humanely raised product. However, we know that people tend to adjust the stated attributes in choice scenarios to reflect their own opinions. The attributes imputed by individuals, in some cases, are a mix of the stated attribute and the person’s own opinion on the matter.<sup>19</sup>

People’s prior opinions about product attributes, for example the extent to which these proposed standards would improve the well-being of animals, are subjective. These opinions depend upon the individual’s perceptions of how badly farm animals are currently treated on the average industrial farm. Many people devote little or no thought to the quality-of-life of the animals they consume as food. Similarly, many different peer group opinions and other influences affect the individual’s subjective assessment of the healthiness of humanely raised meats relative to conventional meats, as well as the extent to which the individual will be thinking about antibiotics, growth hormones, or genetic engineering, and how these might affect chicken products. These key attitudinal variables may need to be considered to be jointly endogenous with the individual’s willingness to pay a premium for either free-range or humanely raised products.

The main implication of endogeneity in these attitudinal variables is that we must exercise caution in simulating how WTP is likely to differ when attitudes differ. If unobserved heterogeneity (not controlled for by our observable respondent characteristics) affects all three attitudinal variables and WTP, it is technically not possible to change one attitudinal variable independently from all the rest to assess its impact upon WTP, even if the three different attitude measures make individually statistically significant contributions to the explanation of choices.

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<sup>19</sup>Respondents’ modifications of stated probabilities is addressed in Burghart et al. (2007) and “scenario adjustment” is investigated in Cameron et al. (2009)

One of our final caveats involves the generalizability of our results. The sociodemographic cross-section of our sample is fairly representative of the state and nation as a whole, with the exception of race. Less than 5% of our sample specifically reports themselves to be nonwhite, which is substantially lower than the national average of 23%. This lack of racial heterogeneity limits how much we can generalize our results to other areas of the country that contain more racial heterogeneity than for the county used for our sample.

To further refine a survey like ours, it would be important to explore ways to gain better experimental control with respect to individuals' subjective perceptions of current animal welfare. It would also be helpful to determine whether there is some way to distinguish between WTP for improved animal welfare itself and WTP simply for more reliable guarantees that claims of humanely raised products are accurate. It may also be possible to exercise additional creativity with respect to the problem of isolating selfish considerations behind a WTP premium, versus exclusively "other-regarding" preferences with respect to non-human species.

## Conclusions

It is often considered somewhat futile to attempt to disaggregate total willingness to pay for an environmental asset when total WTP is comprised of use demand, option demand, bequest demand and existence demand. For example, WTP to protect members of an endangered species from jeopardy probably involves more nuances of environmental value than just the well-being of the individual animal. In this paper, therefore, we have sought to identify a WTP measure for other-species morbidity reductions that is distinct from other reasons for people's WTP. We argue that it may be possible to identify WTP simply to reduce other-species *morbidity* if there is a premium for humane treatment of animals even in the context of a common

and ubiquitous “food animal.” Animals that we eat have no particular symbolic value, as would be the case for the spotted owl as a barometer of the health of old-growth forest, for example. Likewise, they cannot be classed as “charismatic megafauna,” as would be the case for a recently de-listed endangered species like the brown pelican.

For people who consume an animal as food, it is hard to argue that they hold much value for preventing mortality, although vegetarian and vegan consumers may have positive values associated with reduced mortality for these species. If we want to isolate a component of WTP that pertains solely to the well-being of the animal itself, we need a context that is not confounded by symbolic values or endangered species status. We need this information because many of the species which are harmed in an environmental accident (such as the birds that are often affected by a coastal oil spill, for example) are neither endangered nor charismatic species. These relatively anonymous, non-symbolic wild birds sometimes suffer and die in the tens or hundreds of thousands, and it is important to know something about likely patterns in the public’s willing to pay (in advance) to protect these birds. We have thus sought evidence of people’s willingness to pay to reduce harm to the quality of life of other species in a context that is largely divorced from any moral outrage over the source of this harm.

It is worth mentioning that an increase in the well-being of a specific animal, in the context examined in this paper, may be viewed as an essentially private good. At the point of each purchase, the consumer can choose whether to pay a premium for improvements in one animal’s well-being, with certainty. This is in contrast to the case of a referendum on a public policy that would mandate increased protection (reduced risks) for many non-specifically identified individual birds and animals, the cost of which everyone pays.

Our research suggests that, on average for our sample, people are willing to pay perhaps on the order of about \$0.35/lb more for chicken breasts from humanely raised chicken than for conventionally raised chicken, conditional on the assumption (1) that the humanely raised product is no more or less healthy for humans and (2) that people have only moderate levels of concern about antibiotics, growth hormones, and genetic engineering. It is tempting to try to scale the per-pound premium to predict the premium willingly paid for an entire humanely raised chicken, and then to contemplate whether this WTP can be further transferred to each seagull or sandpiper that is harmed by a coastal oil spill, for example. However, this type of extrapolation is probably inappropriate. We have estimated people’s WTP for one physical part of a single identifiable chicken, with certainty. Namely, the particular chicken that the individual is buying on this shopping trip. At most, this same premium might apply to all packages of chicken breasts purchased over the year. However, we have strong suggestive evidence (based on the negative effects of household size, even if we control for income) that the WTP premium is likely to be declining in the number of chickens, per unit time, that are protected by humane standards as a result of the consumer’s choices.

While we are not yet able to scale the WTP premia derived in this study to the problem of valuing reductions in other-species morbidity as a purely public good, our results are unambiguous that certain segments of the population are willing to give up other goods and services to improve the well-being of other species. These benefits from reduced other-species morbidity are *in addition* to benefits from avoided other-species mortality. In terms of a “benefits transfer” to the case of oil-related harm to wildlife in the event of a major oil spill, morbidity-risk values like these would apply to injured birds which survive, and to dying birds between the time they have been oiled and the time they succumb.

Most previous research has focused only upon mortality losses for wildlife, without attempting to value harm to non-human species from non-fatal morbidity or stresses caused by harm to their habitat or disruption of their natural habits. Our research represents a beginning effort to benchmark a disembodied estimate of an average value for morbidity reductions among other species that is independent of the cause of this harm.

## CHAPTER III

### PAYMENT VEHICLES FOR PUBLIC GOODS: EVIDENCE FROM CALIFORNIA STATE PARKS

#### **Introduction**

State park funding mechanisms across the United States have been shifting away from public funding and toward user-based fees for the past 20 years.<sup>1</sup> State parks represent a good that is publicly provided, yet rival when congested.<sup>2</sup> Economic theory suggests that without some public funding, state parks would be underprovided. Theory also suggests that without some marginal cost to users, state parks may become congested. State governments spend billions of public dollars annually to maintain these parks for public use, but the shift away from public funding has left many state parks around the country with substantial maintenance and operating budget deficits. As a result, state parks have seen decreased access, diminished services, and in some cases they have been forced to close.

The state park system of California has been significantly impacted by declines in public funding, the trend toward user fees, and the current recession. Funding has deteriorated to the point that deferred maintenance in CA state parks is estimated to be in excess of \$1 billion. User fees and concession revenues have served as increasingly important sources of revenue for state parks in California, but per capita public expenditures have declined by 33% in the last 10 years. Together, these two

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<sup>1</sup>One example of a user-based fee system is the Northwest Forest Pass (NWFP) program, under which users purchase an annual pass for unlimited admission to publicly maintained areas in the Pacific Northwest.

<sup>2</sup>A good is rival if one person's use of the good prevents another person from using the same good.

sources of revenue comprised over half of the state park department’s overall revenue stream in the 2010-2011 fiscal year.<sup>3</sup>

As a result of these funding difficulties, the State Parks and Wildlife Conservation Trust Fund Act appeared as Prop21 on California’s November 2010 ballot. In this citizens’ initiative, voters were asked to authorize an \$18 per year increase in non-commercial vehicle license fees to place \$250 million per year in a dedicated fund for California’s state parks.<sup>4</sup> In exchange for these fixed fees assessed on every vehicle-owning household, non-commercial vehicles registered in the state would no longer have to pay a marginal user fee to enter, or park at, state parks and beaches. Fewer than 43 percent of voters approved of the proposed shift in funding, however, so Prop 21 failed. As a consequence, 25 percent of California’s 278 state parks are scheduled to close by July 2012.<sup>5</sup>

The histogram in Figure 1 shows the size distribution, aggregated to the level of roughly 7000 Census tracts, of the proportion of affirmative votes for Prop 21. A detailed Appendix accompanies this paper, and the corresponding spatial distribution of voting proportions can be found in Appendix Figure A.6. Together, the size and spatial distributions demonstrate the extent of heterogeneity in voter support for Prop 21 across the state. We explore this heterogeneity—along with the vast differences across California in income levels, sociodemographics, political ideologies, park salience, and the availability of substitutes for state parks—to build

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<sup>3</sup>Some statistics concerning the recent history of park funding are summarized in the online Appendix to accompany this paper. See Appendix Figures A.1, A.2 and A.3.

<sup>4</sup>Gross revenues from the proposition were expected to be \$500 million. The net figure accounts for the money that would have gone back to the general fund and lost user fee revenue.

<sup>5</sup>The map in Appendix Figure A.4 shows the locations of the individual state parks within twelve regions of California; Appendix Figure A.5 shows the locations of the 70 parks which are currently scheduled to close. The choice of which parks to close was made based on the following criteria: (1) protect the most significant natural and cultural resources, (2) maintain public access and revenue generation to the greatest extent possible, and (3) protect closed parks so that they remain attractive and usable for potential partners.



a statistical model to explain voting outcomes for Prop 21. Our primary research objective is to identify which factors best explain variation across Census tracts in the apparent demand for state parks as public goods. Second-order questions include the following: (1) Might there have been a lower statewide vehicle license surcharge at which Prop 21 would have passed? (2) How different would other economic and sociodemographic conditions need to have been, for Prop 21 to have passed? (3) Does our model for California’s vote have the potential to predict the likely popularity of a similar funding changes in other areas of the country?

These questions motivate our research. After spatially aggregating or disaggregating the relevant data to the common spatial unit of Census tract, we construct a data set of Prop 21 voting results and other economic and sociodemographic characteristics. In particular, we construct variables that measure the gross price of Prop 21 to households, household income, proxies for environmental preferences, trust in government fiscal responsibility, the availability of substitutes, and the likely salience of state parks to voters in each tract. Using these variables, we characterize demand for the provision of state parks as public goods.

We also counterfactually simulate the extent to which California conditions, and/or the preferences of Californians, would need to have differed for the Prop 21 to have passed, *ceteris paribus*. We find that demand for Prop 21 is sufficiently insensitive to the gross price that there is no lower statewide vehicle license fee at which it would have passed, although there exists considerable heterogeneity, at the tract level, in the size of the license fee that would have produced a predicted 50-50 vote. We also show the extent to which more-liberal political preferences and greater sympathies for the environment might have led to a state-wide majority in favor of Prop 21. Finally, we use county-level hold-out samples to demonstrate how well our empirical model performs in making predictions about out-of-sample areas.

Several studies examine user responses to aspects of park management policies (see Mansfield et al. (2008); Kerkvliet and Nowell (2000); Loomis and Keske (2009); Crompton and Lue (1992)). There is also a body of work using stated preference methods to examine how people value public parks, both domestically and in other countries (see Carson et al. (1994); Shechter et al. (1998); Baral et al. (2008); Jacobsen and Hanley (2009); Jacobsen and Thorsen (2010)). Some works apply novel estimation techniques to stated preference data to derive WTP values for protection of state parks (see Fernandez et al. (2004), Czajkowski and Hanley (2009), Hanley et al. (2009), Scarpa et al. (2010)), whereas other authors undertake qualitative studies of attitudes toward park funding (Peters and Hawkins (2009) and Fix and Vaske (2007)).

This study belongs to the class of literature that uses referendum voting results to determine demands for public goods. Similar studies in this class include Deacon and Shapiro (1975), Kline and Wichelns (1994), Kahn and Matsusaka (1997), Kahn (2002), and Messer et al. (2010), who use U.S. data to characterize support for environmental referenda. Thalmann (2004), Halbheer et al. (2006), Bornstein and Thalmann (2008), Bornstein and Lanz (2008), and Schulz and Schlapfer (2009) use Swiss voting data with similar objectives.

The seminal paper in this literature is Deacon and Shapiro (1975), who model California voters' choices on referenda about conservation of the California coastline and public funding for rapid transit.<sup>6</sup> The empirical strategy in this paper is an adaptation of the model developed by Deacon and Shapiro and is similar to that of Kahn and Matsusaka (1997), who characterize demand for environmental goods in general using voting results from all of California's "environmental" public referenda

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<sup>6</sup>Fischel (1979) uses a separate survey of voters to test different determinants of voting behavior in a referendum at the local level on a proposed paper and pulp mill in New Hampshire.

between 1970-1994. They find that environmental goods are normal goods at mean income levels and become inferior goods at higher income levels, especially when the environmental good is park land. Interestingly, in contrast to our own findings, they conclude that little explanatory power is sacrificed by omitting controls for political ideology as long as other important characteristics of the population are included in their models.

Kotchen and Powers (2006) use the annual LandVote survey to investigate how voter support for public acquisition of open space depends upon the proposed funding mechanism and funding rate. They find that bonds are preferred to taxes and, in many cases, the difference between financing with a bond or through taxes determines whether a referendum passes. These findings are consistent with our results. Finally, Wu and Cutter (2011) innovate in their recent study of voting on several environmental referenda by disaggregating their data to the level of the Census block-group and using spatial econometric methods. In their analysis, allowing for spatial dependence in both the dependent variable and the error term substantially reduces the magnitude of most coefficients, implying that simple OLS methods may produce biased estimates. They also conclude that results derived using county-level data may be subject to aggregation bias, suggesting that such course aggregation is inappropriate for referendum studies. We use spatial regression methods as a robustness check of our tract-level results.

Our paper makes three main contributions to the literature. First, we include a wider array of economically important explanatory variables than has been used previously in this literature, paying particular attention to the local availability of substitutes and state park salience. Second, we test the relative importance of some of the popular arguments about why Prop 21 failed. Third, given the substantial heterogeneity in California's population and geography, we rotate through

a complete set of county-level hold-out samples to examine our model’s potential to forecast likely popular support for measures proposing similar changes in park funding mechanisms for other parts of the country.

The rest of the paper is organized as follows: Section 2 outlines a model of individual voter choice, which motivates the selection of variables for our empirical specification. Section 3 describes our data. Sections 4 and 5 present our main estimating specifications and discuss the implications of the fitted models, and Section 6 concludes.

## Conceptual Framework

The raw data consist of individual voters’ choices, aggregated to the precinct level, which we further aggregate to the tract level. We now present factors that are part of an *individual* voter’s decision process on the rationale that these are likely to be reflected in collective decisions the tract level.

Suppose that voters derive utility from their net income, their number of park visits, and the perceived equity differences between the status quo and Prop 21. To simplify the model, assume that only one park is relevant to each voter, and abstract away from the opportunity to buy annual passes for park use. Let  $Y_i$  be annual household income for voter  $i$ , where  $i = 1, \dots, N$  indexes all voters. Further, let  $x_i(Y_i, t_i, s, q)$  be park visits per year, where  $t_i$  is the voter’s full travel cost of reaching this park (which depends on the distance at which voter  $i$  lives from the park),  $s$  is a park’s marginal entry or parking fee, and  $q$  is a measure of park quality. Let  $k$  be the proposed surcharge per vehicle and  $v_i$  be the number of vehicles in the voter’s household.

Park quality *without* Prop 21, as a function of total funding and congestion levels, would be

$$q^0 = q \left\{ \left[ G^0 + s \left( \sum_{i=1}^N x_i(Y_i, t_i, s, q^0) \right) \right], \sum_{i=1}^N x_i(Y_i, t_i, s, q^0) \right\} \quad (\text{III.1})$$

This equation illustrates two important points. First, overall funding is equal to current government funding,  $G_0$ , plus aggregate user fees. As illustrated in Equation III.1, there is zero additional revenue from the proposed vehicle surcharge without Prop 21. Second, quality is endogenous because of congestion. The level of congestion at the park is defined as the aggregate number of trips by all households  $i$ , at the status quo level of park quality,  $q^0 \sum_i x_i(Y_i, t_i, s, q^0)$ , where the utility maximizing number of trips for each individual depends on park quality. However, more trips implies greater congestion, which is assumed to decrease quality.

Park quality *with* Prop 21 would improve to

$$q^1 = q \left[ \left( G^1 + k \sum_{i=1}^N v_i \right), \sum_{i=1}^N x_i(Y_i, t_i, 0, q^1) \right] \quad (\text{III.2})$$

where some of the regular government funding  $G^0$  would be diverted to other uses such that  $G^1 < G^0$ . Aggregate revenue from user fees  $s \left( \sum_{i=1}^N x_i(Y_i, t_i, s, q^0) \right)$  would now disappear and be replaced by aggregate revenues from the proposed vehicle surcharge,  $k \sum_{i=1}^N v_i$ . Provided that total funding would increase as a result of Prop 21, we expect quality to improve. However,  $s = 0$  implies a lower visitation cost, which may also increase congestion and decrease quality. If quality declines, so will demand, perhaps sufficiently to offset the increase in trips that would otherwise occur because of lower overall per-trip costs.

Let voters' utility levels with and without Prop 21 be give by  $V_i^1$  and  $V_i^0$ . If voters perceive different distributional consequences with and without Prop 21, the

equity consequences of the two funding mechanisms,  $E_i^1$  and  $E_i^0$  will differ.<sup>7</sup>

$$\begin{aligned} V_i^1 &= U_i \left[ (Y_i - kv_i), x_i(Y_i, t_i, 0, q^1), E_i^1 \right] + \eta_i^1 \\ V_i^0 &= U_i \left[ (Y_i - sx_i(Y_i, t_i, s, q^0)), x_i(Y_i, t_i, s, q^0), E_i^0 \right] + \eta_i^0 \end{aligned}$$

Substituting Equations (III.1) and (III.2) for  $q^0$  and  $q^1$  in the above two equations would allow us to express utility as complex functions of all of the factors discussed above. The individual can be expected to vote in favor of Prop 21 if expected utility under Prop 21 is greater than expected utility without Prop 21, or if  $V_i^1 - V_i^0 > 0$ .<sup>8</sup>

Most of the discussion in advance of Prop 21 appeared to revolve around the increase in revenue and therefore the increase in park quality, which would probably increase park visitation since per trip access costs would be reduced by the amount of the user fee (although ordinary travel costs would remain). However, the vehicle tax would reduce net income, so that the fact that park trips would become relatively cheaper would be offset by the decrease in household net annual income for car-owning households.

With microeconomic data at the level of individual votes and individual values for all of the observable determinants of utility, voting decisions could be modeled using individual discrete choice methods. Unfortunately, this model of individual voters' choices is not easily aggregated to provide a corresponding model of the collective voting behavior by residents of Census tracts. Nevertheless, it highlights some of the factors that we should attempt to include in any empirical model to explain the percent of yes votes in each census tract. For example, our available data

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<sup>7</sup>Cai et al. (2010), for example, demonstrate that the perceived distributional consequences of alternative policies can have a systematic influence on popular support for those policies.

<sup>8</sup>Since voter pamphlets were silent on the issue, we ignore the complication created by the endogeneity of congestion levels

permit us to capture median tract incomes, as well as average household costs of Prop 21 based on average household vehicle holdings. Travel costs can be partially proxied by distance to the nearest park. While we cannot observe demand for park visits directly, we control for a wide variety of factors that collectively capture systematic variation in likely park usage across different types of populations. We also introduce ratings data for municipal and school bonds – in part because they may serve as a proxy for voter confidence that governments will not be tempted to divert existing park spending to other programs, which would negate some of the expected benefits resulting from the vehicle surcharge.

Many of the other variables in the estimating specification are included to account for heterogeneity in the marginal utility of net income, which we expect to depend upon income levels. We include additional variables to account for heterogeneity in the marginal utility from park visits, which we expect to depend upon tastes in recreation and upon the number of locally available good substitutes for state parks.

The underlying voter choice model also suggests that it may be valuable to control for existing levels of congestion at the parks nearest each voter or census tract. Unfortunately, uniform statewide historical visitation data for California’s State Parks appears to be limited. To the extent that congestion will affect perceived park quality, and if voters were worried about congestion increasing even further at their favorite parks, we expect to see fewer yes votes for Prop 21.

## **Data**

To conduct our analysis, we have gathered data from several different sources. Precinct-level voting results for all of the ballot measures and the gubernatorial candidates for the November 2010 election in California are drawn from the Statewide

Database (SWDB) maintained by University of California, Berkeley.<sup>9</sup> The SWDB also contains gubernatorial election results, which we used to proxy for political preferences. We purchased proprietary vehicle registration data from Polk, Inc. to construct our variable for gross price per household and one proxy for environmental preferences.<sup>10</sup> We also collected school-district and municipal-level bond ratings data from the California Department of the Treasury to proxy for trust in government fiscal responsibility. Five-year (2005-2009) average sociodemographic characteristics at the Census tract level come from the American Community Survey (ACS) of the U.S. Census Bureau and are used to account for the age distribution, racial and ethnic composition, occupational and industry mix, and types of households.<sup>11</sup> As a measure of park salience, we gathered hunting and fishing license information from the Department of Fish and Game. Finally, we use Geographic Information Systems (GIS) methods to construct measures of state park salience and substitutes, and to normalize all data on the common spatial unit of Census tracts.

The voting data for Prop 21 are available at the precinct level, but since few other variables are available at that spatial level, we use ArcGIS to aggregate voting data to the Census tract level, based on the spatial overlap between Census tracts and voting precincts. Other explanatory variables were available only the level of zip codes, municipalities, school districts, or Congressional districts. Implicit in all aggregation or disaggregation is the assumption that the distributions of different variables are approximately uniform within their respective spatial extents.

Of the 7049 Census tracts in California, occasional missing data results in 6795 tracts being included in our final estimating data set. Table 6 shows descriptive

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<sup>9</sup><http://swdb.berkeley.edu/>

<sup>10</sup><https://www.polk.com/>

<sup>11</sup><http://www.census.gov/acs/www/>



statistics broken out by category of variable. Average tract-level support for Prop 21 was 43%, with some tracts showing as little as 9% support and others supporting the proposed change with nearly 85% of the vote. The average gross price in terms of household vehicle fees was \$43.60 and the average of median household incomes across tracts was \$65,212. Statewide, there was much more support for the Democratic gubernatorial candidate (Jerry Brown) than for the Republican gubernatorial candidate (Meg Whitman). Across tracts, the average gubernatorial vote share for the Democratic candidate was 57.6%, while the average share was 36.8% for the Republican candidate. The average distance to a state park from the centroid of a tract is 7.2 miles, although some tracts are as far as 90 miles from their closest state park. Finally, the average number of local parks within a 20 km radius of a Census tract is 120, while some Census tracts are near no local parks and some have as many as 450 in that same radius.

For October, 2010, we purchased registration data for over seven million make/model/year combinations in California at the zip code level from Polk, Inc. We use these data to construct our census-tract average gross price per household variable.<sup>12</sup> We argue that the total cost to each household is more likely to have affected voting decisions than the cost to individuals within a household. Therefore, the average number of vehicles per household in each Census tract, times \$18, represents the gross price implied by the proposition. Variation in gross price, shown in Figure 2, is identified entirely by the heterogeneity in vehicles-per-household across Census tracts. Zip codes are slightly larger than Census tracts, so we assume

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<sup>12</sup><https://www.polk.com/>

that vehicle holdings are uniformly distributed within zip codes to permit us to disaggregate this information to the Census tract level.<sup>13</sup>

We proxied for environmental preferences with several different variables. To determine which variables to use, we turn to the literature. Using each community’s share of Green Party registered voters as a proxy for its degree of environmentalism, Kahn (2007) finds that environmentalists are more likely to commute by public transit, to purchase hybrid vehicles, and to consume less gasoline than non-environmentalists. Kahn and Vaughn (2009) find that hybrid vehicles and LEED-registered buildings tend to cluster in environmentalist communities, where such communities are defined by a factor analysis across political party registrations and voting on binding statewide environmental initiatives. Our first environmental preference variable is the proportion of hybrids per total vehicles in a tract. We also consider the explanatory power of the proportions of pickup trucks and SUVs in each tract. It is possible that pickup trucks are a mix of work and recreational vehicles, but that SUVs reflect vehicles purchased primarily for recreational purposes. Finally, we collect data from the League of Conservation Voters (LCV) to capture the environmental voting patterns for an area’s legislators.<sup>14</sup>

Park salience is likely to be an important determinant of demand as well. Deacon and Schlapfer (2010) find that voter support is related to the distance at which environmental improvements are likely to occur. We suspect that the distance to a state park is correlated with demand for state park visits because the closer an individual lives to a state park, the lower will be the travel cost to access that

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<sup>13</sup>We dropped several Census tracts characterized by relatively few households and very large numbers of vehicles, leading to implausibly large average numbers of vehicles per household in some cases. Polk Inc. confirmed that vehicles housed at new and used car lots are included among the registered vehicles in a zip code.

<sup>14</sup>Appendix Figure A.8 shows the distribution of the proportion of hybrids across Census tracts. We obtain LCV scores for California from [www.lcv.org](http://www.lcv.org).

park. Using the intuition of the travel cost model, we expect that lower benefits are approximately equivalent to those benefits being farther away. In addition, due to locational sorting, voters' outdoor preferences are likely to be somewhat correlated with proximity to state parks. Finally, we expect some overlap between park salience and participation in ecosystem-based activities such as hunting and fishing. California's Department of Fish and Game (DFG) began partial implementation of its electronic hunting and fishing license system during the summer of 2010. We use license data from the Automated License Data System (ALDS) for November 2010-October 2011, which is the first complete annual cycle for these digitized data.

Arora and Cason (1999) find that proxies for the tendency of communities to engage in political action seem to have a greater influence on environmental outcomes in non-urban areas. We use the physical area of a Census tract to proxy for the degree of urbanization. Tracts are designed to keep the population sizes relatively similar across tracts, so they tend to be larger in rural areas than in urban areas. We expect the demand for state parks will increase with degree of urbanization since state parks are more scarce in heavily populated areas.

The demand for state parks is also likely to be related to the availability of both recreation-related and non-recreation substitute opportunities. To capture the local spatial density of substitutes, we construct 20 km buffers around the centroid of each Census tract and identify the number of substitutes of different types within that buffer. Substitutes include any feature that is designated as a State Park, State Beach, State Recreation Area, State Wilderness Area, or State Historical Site. We also identify sites designated as National Park, National Seashore, National Recreation Area, or National Wilderness. We designate other similar sites managed at lower levels as "Local". These include anything falling into the category of Local

Park, Local Beach, Local Recreation Area, Local Wilderness Area, or Local Historical Site.

Focus groups convened by The Nature Conservancy identified mistrust of government fiscal responsibility as one of many reasons given by voters for their decisions to oppose Prop 21. One reason was that they did not trust the California state government to make appropriate use of the extra funds that would be collected by Prop 21. Moreover, Dyck (2010) finds that mistrust of government is a consistently robust predictor of conservative policy choices. Unfortunately, any measure of the California *state* government's level of fiscal responsibility is constant across all jurisdictions. To build a proxy indicator for government fiscal responsibility that varies across Census tracts, we argue that trust in a local government's ability to manage its finances responsibly, as measured by municipal and school district bond ratings, may affect voters' propensities to vote for a proposition that gives the government more tax revenue.

We obtained data on municipal and school district bond ratings from the office of the California Department of the Treasury.<sup>15</sup> These data contain all bonds issued in California during 2010 by elementary school districts, high school districts, and unified school districts, as well as those issued by other types of municipal entities. The bonds include ratings from at least one, if not more, of the three standard municipal bond rating agencies.<sup>16</sup> Using these data, we construct a measure of trust in government across Census tracts. To create a measure the quantity and quality of debt associated with a tract, we identify the municipal and school bonds associated with jurisdictions that overlap each Census tract, and we calculate the proportion of debt that is highly rated versus that which is rated less highly. Tracts contain

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<sup>15</sup><http://www.treasurer.ca.gov/cdiac/debtdata/excel.asp>; <http://www.californiacityfinance.com/>

<sup>16</sup>Standard and Poor's, Moody's Investors Service, and Fitch

entities with different levels and risks of debt, so we have variation in levels of this indicator across tracts.<sup>17</sup> We expect that lower-rated municipal or school bonds in a Census tract will be associated with a lower percentage of yes votes for Proposition 21, which would be consistent with a mistrust of government. Alternatively, lower-rated bonds could merely signal that people view their community’s condition as dire, so that any optional expenditure should perhaps be devoted to schools or local public goods, rather than state parks. The Appendix contains further details about how this variable was constructed.

Finally, we obtain income and other sociodemographic information from the American Community Survey (ACS), which provides five-year (2005-2009) averages of sociodemographic characteristics at the Census tract level. These data give us measures of over 300 sociodemographic characteristics of interest, including the income distribution and median household income variables mentioned above—necessary for any sensible demand model. In our model, we also control for occupations, industries, the age distribution, race/ethnicity, and some particular types of household structures (i.e. single moms).

## Econometric Specification

### *General approach*

We estimate a log-odds regression model to characterize the demand for Prop 21. The dependent variable in the model is

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<sup>17</sup>It is difficult to be confident about more than just a “high” versus a “not high” overall rating across up to three rating agencies. The agencies all have comparable definitions for long term ratings, so a numerical crosswalk was relatively straightforward to establish. With exception of a very few bonds, all fell within the “investment grade” range for all rating agencies that rated them. We decided not to use short term ratings because there is not much variation in them, and they are consequently not very informative. Moreover, trust develops over time, so long term ratings are likely more reflective of voters’ views of government fiscal acumen than short term ratings.

$$\text{logodds}_i = \ln \left( \frac{Y_i}{1 - Y_i} \right) \quad (\text{III.3})$$

where  $Y_i$  is the proportion of yes votes cast in tract  $i$  for Prop 21. The log odds ratio is common in this literature—see Deacon and Shapiro (1975); Kotchen and Powers (2006); Kahn and Matsusaka (1997); Wu and Cutter (2011); Kline and Wichelns (1994)—because this transformation allows the dependent variable to span the entire real line instead of being bounded between zero and one.

The equation we estimate for the full set of California data takes the general form:

$$\begin{aligned} \text{logodds}_i = & \beta_0 + (\beta'_1 \mathbf{Polit}_i) \text{Price}_i + (\beta'_2 \mathbf{Polit}_i) \text{Income}_i + \beta'_3 \mathbf{Polit}_i \\ & + \beta'_4 \mathbf{EnvPref}_i + \beta'_5 \mathbf{Salience}_i + \beta'_6 \mathbf{Subst}_i + \beta'_7 \mathbf{Fiscal}_i \\ & + \beta'_8 \mathbf{Socio}_i + \beta'_9 \mathbf{Econ}_i + \beta'_{10} \mathbf{Ecol}_i + \epsilon_i \end{aligned} \quad (\text{III.4})$$

where  $\text{Price}_i$  is  $\$18 \times \left( \frac{\text{vehicles}_i}{\text{hhld}_i} \right)$ , or the average gross price of Prop 21 per household in tract  $i$ ;  $\text{Income}_i$  is the logged value of median household income (where income is denominated in \$1000 units);

$\mathbf{Polit}_i$  is a vector of variables indicating the approximate proportion of the Census tract voting for the gubernatorial candidate of each of the parties running in the 2010 election. (The Democratic Party candidate's share is designated as the base share, since the Democratic candidate won. The other left-leaning candidates were from the Green Party and the Peace and Freedom Party. The candidates from right-leaning groups were Republican, Libertarian, and from the American Independent Party.)  $\mathbf{EnvPref}_i$  is a vector of variables that includes hybrids as a share of vehicles and other vehicle-related variables, as well as LCV scores during the 2010 Congress;

***Salience<sub>i</sub>*** is a vector of state-park-specific variables including distance to, and size of, the nearest state park as well as the approximate number of fishing and/or hunting licenses purchased by residents of a tract; ***Subst<sub>i</sub>*** is a vector of counts of features which may be substitutes for state parks, located within a 20 km radius of the centroid of the tract; ***Fiscal<sub>i</sub>*** is an indicator for the presence of low-rated municipal or school district bonds in a jurisdiction containing the tract; ***Socio<sub>i</sub>*** is a vector of sociodemographic controls, including income brackets, age, ethnicity, and family structure; ***Econ<sub>i</sub>*** is a vector of variables to capture local economic conditions, including median house values and a measure of current foreclosure risk; ***Ecol<sub>i</sub>*** is a vector of ecological zones within the state of California; and  $\epsilon_i$  is a randomly distributed error term.

Equation (III.4) has microfoundations (Deacon and Shapiro (1975)). However, the data used in this study are aggregate; in particular, they are group averages of a binary variable. While Freedman (1999) warns against committing the “ecological fallacy,” where researchers use relationships derived from group data to make predictions about individual behavior, Coan and Holman (2008) find that aggregate results are “robust to ecological problems.” Similarly, Kotchen and Powers (2006) use aggregate data to make inferences about individual voting preferences, citing Fischel (1979) as sufficient evidence for their interpretation. To avoid the ecological fallacy, we will be conservative and adopt the usual strategy of simply making inferences about group behavior, using the census tract as the unit of observation. We do not claim to be able to recover individual preferences from our parameter estimates, but any regularities we discover may of course be suggestive of new “stylized facts” to be considered in future individual-level studies.

The explanatory variables in equation (III.4) help us achieve our main objective; that is, to characterize the demand for Prop 21 as precisely as possible.

$Price_i$  and  $Income_i$  allow us to assess the responsiveness of demand for Prop 21 as a function of the gross price of the proposition and income levels, while we proxy for expected future incomes using  $Econ_i$ . Inclusion of the political ideology variables,  $Polit_i$ , dramatically increases the fit of our model.  $EnvPref_i$  gives us a glimpse into how environmental preferences shift demand by using vehicle choices (especially hybrids) as proxies for environmental preferences.  $Fiscal_i$  allows us to measure how public trust in the fiscal responsibility of governments may have influenced the demand for Prop 21. We use  $Park_i$  to determine how the nearest state park's characteristics, including size and distance from the census tract in question, affect demand for Prop 21.  $Occup_i$ ,  $Indust_i$ ,  $VehAge_i$ ,  $RaceEth_i$  and  $Family_i$  control for the mix of sociodemographic characteristics represented in each tract.  $Subst_i$  allows us to determine whether demand for state parks is higher when there are fewer good substitutes nearby. Finally,  $Ecol_i$  permits us to determine whether individuals who self-select to live in different types of ecosystems have different preferences for state park funding mechanisms.

We estimate the model initially using ordinary least squares (OLS) with standard errors clustered at the level of the 58 different counties in California. Some other studies have required population-weighted least squares to account for huge differences in population sizes across their political units. However, the spatial extent of Census tracts is defined based upon population so that each tract has roughly between 2000 and 8000 people. Thus we are not particularly concerned about distorted inferences that could stem from vast disparities in populations across the groups for which our variables are summed or averaged. As a robustness check, though, we estimate a population weighted least squares specification to verify that this confidence is warranted.



### *Spatial Regression*

We also explore a spatial regression specification to allow for the possibility of both spatial correlation in the dependent variable and spatial lags in the error structure. We do this because we cannot exclude the possibility that the proportion of yes votes in a census tract is systematically correlated with the proportion of yes votes in neighboring census tracts. Similarly, it is possible that the error terms may be spatially autocorrelated. We follow Wu and Cutter (2011) in estimating a SARAR(1,1) specification, which allows both the dependent variable and the error term to be spatially autoregressive of order 1:

$$\begin{aligned} \log odds_i &= \beta_0 + \rho W_1(\log odds_i) + (\beta'_1 \mathbf{Polit}_i) Price_i + (\beta'_2 \mathbf{Polit}_i) Income_i \\ &+ \beta'_3 \mathbf{Polit}_i + \beta'_4 \mathbf{EnvPref}_i + \beta'_5 \mathbf{Salience}_i + \beta'_6 \mathbf{Subst}_i \end{aligned} \quad (\text{III.5})$$

$$\begin{aligned} &+ \beta'_7 \mathbf{Fiscal}_i + \beta'_8 \mathbf{Socio}_i + \beta'_9 \mathbf{Econ}_i + \beta'_{10} \mathbf{Ecol}_i + u_i \end{aligned} \quad (\text{III.6})$$

where

$$u_i = \lambda W_2 u_{(-i)} + \epsilon_i$$

In equation (5),  $W_1$  and  $W_2$  are inverse-distance weighted matrices;  $\rho$  is a coefficient measuring the magnitude of spatial correlation in the dependent variable;  $\lambda$  is a coefficient measuring the magnitude of spatial correlation in the error terms.

### **Results**

We report the main results of our econometric estimation in Table 7. We will discuss the regression models first, and then consider four simulations, based on

the estimated model, that permit us to answer some of the questions posed in the introduction. We then assess the robustness of our results to alternative estimators and specifications.

Our results are based on 6,795 census tracts for which we have complete data. We focus on a parsimonious model that nevertheless includes all ten categories of available regressors. However, we will discuss in detail only the most important classes of explanatory variables. Column 1a of Table 7 displays parameter estimates and asymptotic t-test statistics for the OLS specification with clustered errors. Standard errors are clustered at the county level to control for common unobserved county-wide phenomena that may be present in the data. Column 1b gives the corresponding marginal effects at the means of the data implied by this specification for those instances where a variable enters with interaction terms. Column 2 shows the same OLS specification with t-test statistics calculated using unclustered standard errors to facilitate comparison of its inferences against those from the model in Column 3, where clustered standard errors are not an available option. Column 3 itself displays results based on a SARAR(1,1) specification like that used in Wu and Cutter (2011), where we allow both the dependent variable and the error term to be spatially correlated.

#### *OLS estimates*

Before examining the effect of price on support for Prop 21, note that the standard economic notion of price does not apply in this situation. Our price measure is *gross* price and not net price. In order to obtain voters' anticipated net prices, we would need to be able to measure the total annual user fees for state parks that households would avoid if Prop 21 passed. We proxy for things that are likely to be positively correlated with expected state park user fee savings due to Prop 21, but

we are referring to just the gross price in our discussion of price. With this caveat in mind, we can consider the effect of gross price on support for Prop 21. As should be expected, a higher gross price tends to decrease the log-odds of the yes vote. The marginal effect of gross price, at the means of the data, is negative and strongly significantly different from zero.

Our next finding is that the marginal effect of income on the log-odds of a yes vote is also negative, suggesting that the switch to public funding of state parks may actually be an inferior good at the means of the data. A possible intuitive explanation is that people who are able to afford a more expensive vacation will take it, rather than visiting a state park or state beach. This income effect is consistent with the results of Kahn and Matsusaka, who find that environmental assets, especially parks, are inferior at higher levels of income. This insight is relevant to the potential distributional consequences of Prop 21 in the sense that a uniform tax of \$18 on all vehicles would tend to be regressive (except for people without vehicles). However, if publicly funded state parks are inferior goods, the savings in user fees represented by Prop 21 could render the overall net cost implications of Prop 21 more progressive than the status quo, since the change could represent a transfer of wealth from higher-income households who do not use state parks to lower-income households who do.

The estimated effects of political ideology are particularly striking. The more Republican-leaning is a census tract, the less likely are its residents to vote for Prop 21, *ceteris paribus*. This is consistent with the findings of Thalmann (2004), Bornstein and Lanz (2008), Bornstein and Thalmann (2008), and Coan and Holman (2008), who find that political ideology has substantial power in explaining variation in support for an environmental proposition. The estimated marginal effects for the political ideology variables in Column 1b of Table 7 summarize their effects at the

means of the data. Not surprisingly, a greater share of Green Party gubernatorial voters in a Census tract is associated with increased support for Prop 21. However, greater shares of Republican gubernatorial votes, or for the candidates of the other minor parties, mean less support for Prop 21. A strong presence of minor parties may indicate a more heavily polarized community, however, which may diminish support for public goods in general.

We turn next to environmental preferences. The share of hybrid vehicles has a coefficient which is positive and highly significant across all specifications in Table 7, suggesting that greater environmental preferences are associated with greater odds that voters in a tract will view Prop 21 favorably. In gathering explanatory variables, we postulated that perhaps a large share of people who purchase SUVs do so because they like to carry camping, hunting, or fishing gear into off-road areas, and these preferences may be associated with a greater demand for state parks. However, the share of SUVs in a census tract has no statistically significant effect on votes for Prop 21. Perhaps the choice of an SUV conveys option demand for such activities for some car owners, but these vehicles may be purchased more because of their other amenities than for actual sport-related uses. As distinct from SUVs, we speculated that pick-up trucks might be predominantly work-related vehicles, so that a greater proportion of them would imply less hauling of recreational equipment and perhaps a greater capacity for payload associated with farming, or with the building or construction trades. The negative effect on votes for Prop 21 as a function of the share of pickups is persistent across specifications and may support this hypothesis. Our final measure of environmental preferences, the League of Conservation Voters (LCV) scores, are statistically insignificant in our OLS models, but significant and *negative* in our model with spatial structure. We suspect that there may be too little spatial resolution at the level of California's federal electoral districts to permit us to get a clear picture

of the potential influence of legislator environmental voting patterns on referendum voting by individuals at the level of the census tract.

We proxy for voters' trust in the fiscal responsibility of government using an indicator for the presence of lower-rated municipal or school bonds. When bond ratings are available for a tract, lower-rated bonds have a negative effect on the proportion of yes votes for Prop 21. These results become statistically insignificant when standard errors are clustered, however. An alternative interpretation for bond ratings is that they may reflect the opportunity cost of Prop 21 in terms of local public projects that would have to be forgone. If this is the case, the negative coefficient may suggest that people in jurisdictions with lower-rated bonds may be more concerned with the need for investment in local public schools or street maintenance than the provision of state parks.

An important class of explanatory variables, unique to this study, is the salience of state parks to voters in a tract. The negative and significant coefficient on distance to the nearest state park suggests that the further is a tract from its closest state park, the less likely were its residents to vote for Proposition 21. However, if the nearest state park is larger, the proportion of yes votes is greater. Smaller tracts (i.e. in more densely populated areas) are more likely to vote for Prop 21. Finally, it appears that per-capita hunting licenses obtained in a tract are negatively associated with support for Prop 21. This could be because hunting is also picking up a "lower income or rural" effect, or it may simply reflect the fact that state parks typically do not allow hunting. Any land devoted to state parks may be viewed by hunters as reducing their access to potential hunting areas.

Among areas designated officially as California State Parks, parks and state beaches comprise the majority of these public lands. It is possible that these various sites are perceived as substitutes. In our models to explain the vote on Prop 21, there

is a negative coefficient on the number of state parks within twenty kilometers of each census tract, but the coefficient on the number of state beaches is unexpectedly positive. However, an important insight here is that being within twenty kilometers of a state beach also means that the tract centroid is within twenty kilometers of the Pacific Ocean, and both property values and incomes tend to be higher near the coast. State parks that are not beaches tend to be inland and in more rural areas, where property values and incomes are typically lower. The local density of state parks, as opposed to state beaches, may thus be picking up a number of other differences across census tracts in California.

We also include in our models a variety of potential substitutes that are very different from state parks. The coefficient on museums is positive. Many museums are located in urban areas, where recreational opportunities may be in relatively short supply. Another speculative explanation is that people who choose to live in areas with more museums may be more inclined to want to preserve things for future generations. Consistent with that explanation, proximity to a greater number of local parks is also associated with greater support for Prop 21 in the OLS model.

We find a negative coefficient on “attractions,” however, which include things such as amusement parks. These represent a very different type of substitute for state parks—much different than other wilderness or natural recreation areas. But they are substitutes nonetheless.

In contemplating the transferability of our findings to other states, it will be important to control for the availability of substitutes for state parks. While many other states do not enjoy California’s endowment of attractive natural areas, California’s geography is large and highly diverse. The state contains the full spectrum of development levels and has many less-attractive “natural” areas as well.

With respect to Census tract age distributions, only the share of 20- to 24-year-olds in a tract has a statistically significant (and positive) effect on the share of votes in favor of Prop 21. People in this age group are typically living on their own, yet are still operating on a relatively tight budget. They are old enough to go to state parks without adult supervision, still earn little enough to appreciate that state parks represent a low-budget break or vacation, and they are still fit enough to walk or hike vigorously.

Of the remaining sociodemographic results, the Hispanic/Latino case may be the most interesting. At the means of the data, it seems that tracts with higher membership in this category are less like to support Prop 21. However, as median tract incomes increase, the effect of a greater share of Hispanics/Latinos is positive, suggesting that higher-income members of this group make greater use of state parks. Cronan et al. (2008) provide evidence to suggest that members of this group tend to enjoy parks as settings for family gatherings in natural surroundings as well as for physical recreation pursuits. Cronan et al. use the results of a national multiyear and multisite study by the USDA Forest Service to show that half of the Hispanic/Latino respondents walked to *city* park sites, whereas few or none walked to state or regional park sites. To the extent that higher-income households in this group find it easier to reach state parks, they are more likely to be state park users.

### *Spatial estimates*

The tiny magnitudes of the statistically significant coefficients on  $\rho$  and  $\lambda$  suggest that the impact of allowing for spatial autocorrelation on our results is unlikely to be substantial. The only notable result in this alternative specification concerns the coefficient on the number of local parks within a 20 kilometer buffer. It is different in sign from the OLS model, suggesting that local parks are complementary

to state parks. This is in contrast to the OLS specification, which suggests that local parks are substitutes. Local parks may be more numerous in communities that display greater demand for public goods in general.

### *Simulations*

We turn now to some of the specific questions we posed at the beginning of the paper. We answer these questions by simulating counterfactual scenarios under which (1) the price of Prop 21 is lower, (2) the population is more liberal, (3) the population is more environmentally conscious, or (4) the population has greater trust in the government's ability to handle its finances.

We first solve for the vehicle surcharge that might have led to a break-even vote in each individual census tract. For each census tract, we use 1000 random draws from the estimated asymptotically joint normal distribution of the parameters to produce both a point estimate and a simulated confidence interval for the predicted break-even vehicle surcharge,  $k_i$ . Our model predicts that for 55.3 percent of tracts, even lowering the per-vehicle surcharge all the way to \$1 would not be enough to achieve a fifty percent vote for Prop 21.<sup>18</sup> For the other 44.7 percent of tracts, however, the simulated vehicle surcharges such that predicted yes votes would reach fifty percent in each tract are depicted across these tracts in Figure 3, which shows the distribution of point estimates of the *tract-level* break-even fees. Although there exists no positive break-even price for 55.3% of the tracts in our sample, some tracts

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<sup>18</sup>The simulation is a linear extrapolation. Evidence of a discontinuous jump in demand at  $p=\$0$  exists in the development literature (Cohen and Dupas (2010), for example) and we have no reason to expect it would be different here.



appear to have been willing to pay upwards of \$150 per vehicle and still collectively pass Prop 21 at 50%.<sup>19</sup>

Alternatively, we could ask whether there might have been some lower common *statewide* vehicle license surcharge, less than \$18, which would have allowed Prop 21 to just pass. This means that the overall proportion of votes, across all census tracts, would have to reach 50%. For this simulation, we must have  $k_i = k$  for all census tracts. The most efficient way to obtain a point estimate of the “break-even” vehicle surcharge is simply to conduct a line-search, starting at \$18 and reducing the price incrementally. Using this strategy, we find that even reducing the per-vehicle surcharge all the way to \$1 would still have been insufficient to pass Prop 21.<sup>20</sup> Voters appear to be rather insensitive to the gross price. One explanation is that people cared more about the payment vehicle for funding Prop 21 than they cared about the actual cost of funding Prop 21.

This explanation is consistent with the results of Nelson et al. (2007) and Kotchen and Powers, who find that municipal open-space conservation referenda are less likely to pass when new taxes are involved. It is also consistent with the results of Johnson (1999), who finds that potential price increases seem to have negligible effects on voter support for the proposed regulation. The explanation is inconsistent, however, with the findings of Halbheer et al. (2006), who determine that the proportion of yes votes does *not* seem to depend upon whether a proposal involves a tax, including cases of environmental taxes as well as public good provision that will require additional taxes for funding. However, the explanation for this difference

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<sup>19</sup>As Appendix Figure A.9 illustrates, there is also substantial spatial heterogeneity in WTP for parks across census tracts.

<sup>20</sup>This is an out-of-sample prediction. In the actual data, the cost to the household of Prop 21 was constant, per vehicle, and we rely on variations in average vehicles per household to pin down the gross price effect.

may lie in different attitudes towards taxes in general in the U.S. versus Switzerland. Matsusaka (1995) and Matsusaka (2005) find that states with direct democracy, such as California, rely less on broad-based taxes and more on user fees, lending further support to the idea that a tax may not have been the proper payment vehicle for the objective that the framers of Prop 21 had in mind.

We turn now to the other questions we posed at the beginning of the paper. We do this by simulating counterfactual scenarios in which the population is more liberal, more environmentally conscious, or has greater trust in the government's ability to handle its finances.

Now consider the effect of the share of votes for the Republican gubernatorial candidate in the same 2010 election. The point estimate suggests that the greater the share of Republicans in a tract, the lower the share of yes votes for Prop 21. This effect is very strongly significant. This raises the question: How much more liberal would tract voting populations need to have been to just pass Prop 21? For this simulation, we fix the minor party gubernatorial vote shares and concentrate on the margin between mainstream Democrats and mainstream Republicans (i.e. we shift only the swing voter between these two parties). To simulate a higher share of Democrats without any shares exceeding 1.0, we manipulate the log-odds of the share of Democratic gubernatorial votes among just the Democratic and Republican votes. We incrementally shift the log-odds of the proportion of Democratic votes across all census tracts by an equal amount, each time checking the predicted effect on the statewide vote in favor of Prop 21 (assuming that voter turnout is unaffected). We iterate until the overall simulated proportion of yes votes for Prop 21, in the state as a whole, just reaches fifty percent. Figure 4 shows the substantial increase in the proportion of Democrats (at the expense of Republicans) that would have been necessary for Prop 21 to pass, holding every other factor constant.

We also simulate an increase in environmental consciousness by holding all other factors constant and increasing the proportion of hybrid vehicles in each tract by a uniform amount across all tracts until the predicted statewide vote just reaches fifty percent. (This proportion never approaches 1.0 in any tract, so it is unnecessary to work in terms of the log-odds in this case.) The observed proportion of hybrids averages 0.00273 across census tracts in our sample. Assuming that voter turnout would have been no different, our model predicts that if the average share of hybrid vehicles had been 0.01227 (and had the actual environmental sentiments this share represents changed accordingly), Prop 21 would have just passed at the statewide level.

Finally, we simulate full trust in government fiscal responsibility as measured by bond ratings for municipalities and school districts. For the simulation scenario in which all municipal and school bonds fall into the “highly rated” category, the predicted proportion of yes votes across the state would shift only from 0.424 to 0.428. This measure of trust matters statistically, but it makes little difference to the overall voting outcome on Prop 21.

### *Hold-out Samples and Out-of-Sample Predictions*

As mentioned in the introduction, an understanding of the determinants of support for Prop 21 across the different regions of California may provide a tool to predict likely support for a similar proposition in other direct democracy states, or popular support for similar legislation in states that do not practice direct democracy. We thus explore the extent to which our model might succeed in forecasting the vote for Prop 21 in other jurisdictions. Ideally, we would gather analogous explanatory variables for Census tracts in other states to judge the predictive ability of our model. However, no other states have conducted such a vote, so we would have no way to

assess predictive validity in such a case. Instead, we use hold-out samples of census tracts from the California data as proxies for other states.

Specifically, we rotate through each of the counties of California, excluding its constituent Census tracts from the estimation process. We save the estimated parameters of the model and use them to predict the share of yes votes in each of the tracts of the hold-out county. To ensure that the variability in the parameter estimates is reflected in our prediction about the voting outcome for the hold-out county, we use simulation methods to generate both point and interval estimates for our predicted overall vote shares in each hold-out county. We make 1000 draws from the joint distribution of the parameters. For each draw, we calculate fitted vote shares for every tract, apply these to the observed voter turnout, and then aggregate yes votes as a share of total votes across the entire county. Across the 1000 parameter draws, we build up a sampling distribution for the county-level vote share.<sup>21</sup>

Table 8 summarizes, for each hold-out county, the results of our tests of the out-of-sample forecasting ability of our model. The mean simulated county-level vote share in the column labeled “Point” (under “Fitted Share Yes”) is very close to the actual share of yes votes at the county level for most counties. We also provide the 95 percent interval for each prediction, as implied by the 2.5th and 97.5th percentiles of the simulated distribution of the share of county-level yes votes.

Table 8 demonstrates that, based on point predictions, the simple passage or failure of Prop 21 is correctly predicted for 55 of the 58 different hold-out counties. In two of the three cases where the mean prediction is wrong, the interval estimate for the share of yes votes includes 0.5 so that either outcome was possible. For only one holdout county (Siskiyou) did our model predict failure unambiguously when Prop 21 actually passed.

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<sup>21</sup>If voter turnouts were unknown, they might be estimated based on prior elections

Prop 21 actually passed in eleven of California’s 58 counties. In seven of these cases, our *interval* estimate predicted passage unambiguously. In three other cases, the prediction interval included the possibility of passage. For 52 of the 58 holdout counties, our 95% interval predictions yield an unambiguous forecast of passage, or an unambiguous forecast of failure, of Prop 21 (i.e. the simulated 95% interval excludes 0.5). These predictions are correct in 51 of these 52 cases.

Finally, we might wish instead to treat the *actual* county share of yes votes as our prediction of interest, rather than just the passage or failure of the Proposition at the county level. Table 8 shows that the actual point value of the county-level vote share is captured by the 95 percent prediction interval for 26 of the 58 hold-out counties. If we expand the prediction interval to 99%, however, the actual county vote share lies within the prediction interval in 46 of the 58 cases, with these cases shown simply as check marks in the final column of Table 8.

There is considerable heterogeneity across California counties in our explanatory variables. To the extent that this heterogeneity also spans the variation across the U.S. in these same explanatory variables, the degree of prediction success across hold-out counties within California is encouraging for the likely prediction success of our California model, were it to be transferred to other states.

### *Robustness Checks and Falsification Tests*

We test for the possibility that our results could be distorted because we are not accounting for differences in voter turnout or population across Census tracts. Additionally, one might wonder whether the econometric model in this paper *uniquely* explains the variation in the vote for Prop 21 or if it may also explain variation in the votes for other statewide propositions on the November 2010 ballot. It is also

reasonable to question whether the variables that explain variation in the vote for Prop 21 may also be explaining voters' propensities to vote.

As a robustness check, we run a voter-weighted grouped logit and compared those results to the full model from Table 7. We also test to see if heterogeneity in population sizes may be influencing our results. By construction, Census tracts tend to contain between 2000 and 8000 people. Although the variation in population is not large, we confirm that variation in population is not driving our results by comparing results from a population-weighted OLS model to our full unweighted OLS model. These results appear in Appendix Table A.1 and confirm that neither alternative estimator gives qualitatively different estimates than our preferred OLS model.

As a falsification test, we compare our fitted model for Prop 21 with analogous models to explain other referendum voting results from the same election. Specifically, we consider Prop 22 (The Local Taxpayer, Public Safety, and Transportation Protection Act) and Prop 26 (Supermajority Vote to Pass New Taxes and Fees Act). Prop 22 prohibits the state, even during a period of severe financial hardship, from delaying the distribution of tax revenues for transportation, redevelopment, or local government projects and services. Prop 26 requires that certain state fees be approved by two-thirds vote of Legislature and certain local fees be approved by two-thirds of voters. Both propositions concern how the government will handle tax revenues, but they arguably have nothing to do with parks or other environmental public goods.

We estimate specifications identical to Model 1a in Table 7 for these two other propositions, with the results appearing in Appendix Table A.2. Let the estimates for Prop 21 be "Group 1" and the estimates for Prop 22 and Prop 26 be "Group 2." Of the 76 estimated coefficients, we compare coefficients on the same regressor across the

two groups and focus on those cases where there is at least one statistically significant coefficient in each group. For 32 of the 76 coefficients, the signs on the statistically significant coefficient estimates differed across groups. For 42 other coefficients, the slopes were statistically insignificant in one or both groups. For only two coefficients were the signs the same, with at least one significant coefficient in each group. In both of those cases the sizes of the coefficients differed across groups by an order of magnitude. Next, we save the residuals for our preferred specification explaining voter support for Prop 21 and the other specifications explaining variation in support for Propositions 22 and 26. We obtain pairwise residual correlations between Prop 21 and Prop 22 and between Prop 21 and Prop 26. If our full set of explanatory variables was explaining the variation in support for Prop 21 vs Prop 22 and Prop 26 equally well, we would expect the residual correlations to be close to 1. Instead, the correlation between the residuals of Model 1a in Table 7 and the analogous specification for Prop 22 is just -0.337 and the residual correlation between Prop 21 and Prop 26 is -0.564. We conclude that the data-generating process that led to voting patterns for Prop 21 is fundamentally different from that which led to voting patterns on Prop 22 and Prop 26. Notably, *none* of the coefficients for state park substitutes are statistically significant for Prop 22 or Prop 26.

Finally, we confirm that our model is not simply explaining voter turnout. If it was, we would expect that our full set of explanatory variables to explain well the variation in voter turnout for the same election in which Prop 21 occurred. As an additional falsification test, we regress the log odds of the proportion voters who voted on the full set of explanatory variables employed in Table 7. These results appear in Appendix Table A.3. Of the 76 estimated coefficients, we compare coefficients on the same regressor across the two regressions and once again focus on those cases where there is at least one statistically significant coefficient in each group. For 11 of the

76 coefficients, the signs on the statistically significant coefficient estimates differed across regressions. For 54 other coefficients, the slopes were statistically insignificant in one or both regressions. For another 11 coefficients, the signs and significance were the same. In those cases the sizes of the coefficients differed across groups by an order of magnitude. Next, we save the residuals for both our preferred specification explaining voter support for Prop 21 and the voter turnout specification and obtain the correlation between the residuals. The correlation between the residuals of Model 1a in Table 7 and the analogous specification for voter turnout is just 0.0617, allowing us to once again conclude that the data-generating process that led to voting patterns for Prop 21 is different from that which led voters to vote.

## Conclusion

The purpose of this paper has been to identify which factors were most important in explaining the substantial variation across California in support for Prop 21 on the November 2010 ballot. To do this, we construct a rich set of data with a larger variety of economically motivated explanatory variables than has previously been used in the literature. Our key explanatory variable is the average number of vehicles per household, used to determine the average annual gross price of the proposition to households in each tract. Three main questions motivate our study.

1. Could there have been a single lower statewide vehicle-license surcharge at which Prop 21 may have passed?

Almost 43 percent of California voters did vote in favor of Prop 21, so it is reasonable to wonder whether Prop 21 might have passed had the fee been less than \$18 per vehicle. We simulate lower fees per vehicle. The results suggest that there is no lower statewide fee at which Prop 21 would have passed, all



other things equal. We also use our model, on a tract by tract basis, to solve for the highest per-vehicle fee that would have produced 50% support in each tract. These fitted break-even fees display substantial heterogeneity across tracts. Although the majority of census tracts in the state would not have passed Prop 21 at any positive price, our model suggests that, in some tracts, the proposition would have just passed at per-vehicle fees as high as \$50 to \$100.

2. How different would other economic and sociodemographic conditions have needed to be for Prop 21 to have passed?

(a) More trust in government fiscal responsibility: The coefficient on the presence of lower-rated municipal or school bonds, which represents our local proxy for trust in government fiscal responsibility, is statistically significant and negative in the specification where we allow for spatial autocorrelation. We suggest a couple explanations for this. First, a presumably less-favorable view of how responsibly government entities manage the money they raise corresponds to less support for Prop 21. Second, voters may have had a greater concern for the financial needs of local government as opposed to those of state park management at the time of the vote.

(b) A more liberal electorate: The mix of political ideologies represented in each census tract has a large influence on the proportion of votes for Prop 21. Our simulations suggest that it would have taken a substantial shift toward the left by swing voters for Prop 21 to have passed statewide.

(c) Greater environmental sympathies: Stronger preferences for the environment, as proxied by the proportion of hybrid vehicles in a tract,

could have pushed Prop 21 to pass at the state level. Our simulations suggest that environmental preferences consistent with a four-fold greater share of hybrid vehicle ownership could have passed Prop 21, all else constant.

3. Could the predictions of our model be used to ascertain the likely success of a similar voter initiative passing in other areas of the country?

California is a big state with a large amount of geographic, sociodemographic, and political heterogeneity. Inasmuch as the voters in another state at a different point in time have characteristics spanned by the conditions represented across California in November of 2010, it might be possible to use our model to forecast likely support for a similar measure in those other areas of the country. While our model does not permit inferences about *individual* voting behavior, our covariates explain almost 87 percent of the variation in support for Prop 21 at the census tract level across California. In addition, our hold-out sample analysis indicates good in-state predictive ability, which increases our confidence that the empirical model could be used for predicting success of a similar measure in another part of the country.

There are, of course, other potential explanations for why Prop 21 failed. For example, Li et al. (2011) find that people are significantly less likely to give to government charity organizations than to private charities, and national organizations attract more donations than do local and state organizations. Moreover, they find that people are much more willing to be voluntarily taxed when the public good in question is cancer research as opposed to education, national parks and wildlife, or disaster relief. It is possible that many people in California

may have had other demands for charitable contributions on their minds at the time of the election.

There are many reasons why the nature of state park funding mechanisms is a socially relevant issue. One is the potential distributional consequences of different possible funding mechanisms. There exists evidence that Prop 21 was an “inferior” economic good at the means of the data, implying that tracts with lower median incomes were actually more likely to vote for the proposition. This could be true if a prolonged recession causes people to anticipate that they may need to substitute away from more expensive out-of-state vacations and visit state parks instead. Perhaps support for Prop 21 was greater than it would otherwise have been, due to the concurrent recession. In addition, tracts with larger shares of Asian and African-American populations were less likely to vote in favor of Prop 21, suggesting that these groups may derive less utility from access to state parks. However, there is some evidence that Latino/Hispanic populations found Prop 21 more appealing, at least for higher-income tracts with higher proportions of this group.

Another reason that the mode of state park funding could matter, from a societal perspective, is congestion control. In addition to raising revenue from park visitors, user fees were initially implemented in part to manage congestion by imposing a positive marginal price per visit for park users. Depending upon the price elasticity of demand for visits to state parks, a per-visit fee could discourage some types of households from using state parks.

Finally, Siikamaki (2011) finds that the establishment and existence of state parks generates a substantial amount of nature recreation in the general population, the annual value of which he estimates at \$14 billion. Given the growing obesity epidemic in the U.S. population, there may be an argument for the potential positive health-related externalities that could be associated with removing per-trip user fees

that constitute a disincentive to engage in nature-based outdoor recreation. As state parks around the country continue to fall into disrepair because of a lack of funding, this study provides useful information for policy-makers and environmental groups in other parts of the country as they try to solve their own state park funding problems.

## CHAPTER IV

### THE EFFECTS OF ENVIRONMENTAL REGULATION ON DRY-CLEANING FIRM EXITS

#### **Background and Motivation**

The Clean Air Act Amendments of 1990 identified perchloroethylene (PCE) as a hazardous air pollutant (HAP) and therefore subject to regulation. PCE is the chemical used in the most prominent method of dry cleaning. Detrimental health effects tend to occur in individuals who spend extended periods of time in close proximity to elevated levels of PCE, such as workers at, or neighbors of, dry cleaning facilities. This paper examines a panel data set for all dry-cleaning establishments in the State of California during 1990 through 2009, with an eye to quantifying the effects of PCE regulation on this particular industry. The available data begin at the point when the Clean Air Act Amendments went into effect and they span two decades during which even more stringent regulations were implemented. The different timing of similar regulations in two different jurisdictions within California permit a difference-in-differences approach to identifying the effects of regulation on a variety of outcome measures in this industry.

The objective of environmental regulations is to improve environmental quality, but there are usually some economic tradeoffs involved. If this were not the case, then environmental regulations would be unopposed. Economic theory suggests that environmental regulations force the market to internalize otherwise external costs, resulting in fewer units of a good being provided. Overall domestic PCE use began a fairly sharp decline in the 1990's, as illustrated in Figure 5. According to Doherty (2000), the dry cleaning industry was the primary consumer of PCE in

1980. By 2007, the industry accounted for about 10% of the domestic PCE demand but accounts for a disproportionate amount of public exposure due to the numbers and spatial distribution of retail dry-cleaning establishments. (Halogenated Solvents Industry Alliance (2012)) As a subgroup of entities using PCE, the percent of U.S. dry cleaners using PCE peaked around 1980 (86.7%) and has been declining ever since. In 2007, 70% of U.S. dry cleaners still used PCE. In April, 2012, France banned the use of PCE in dry cleaning facilities.<sup>1</sup>

Real action to curb PCE use began in 1994 after the EPA released a report on PCE and its potentially harmful side-effects. That same year, Connecticut and Florida began the first dry-cleaning solvent cleaning programs in the U.S. and Dade County, Florida sued several dry cleaners because traces of PCE were found in groundwater. Meanwhile, California decided the EPA standards were not strict enough and passed its own laws restricting PCE use late in 1993. It was estimated that 40% of dry cleaners would need to install new equipment at a total industry compliance cost of between \$60M and \$90M.

The next round of regulation came more recently, again courtesy of the Clean Air Act. We concentrate on regulation of this industry in the State of California. Under the amended Dry Cleaning Airborne Toxic Control Measure regulations, no new PCE machines could be installed after December 31, 2007 in the state of California. In addition, PCE machines were to be eliminated in co-residential facilities by July 1, 2010, converted machines and machines that are more than fourteen years old were to be removed from service by July 1, 2010, and all remaining PCE machines must be removed from service once they become fifteen years old. This implies that all PCE machines will have to be retired from service by January 1, 2023.

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<sup>1</sup><http://chemicalwatch.com/10853/france-takes-action-on-perchloroethylene-cleaning-chemicals>

The South Coast Air Quality Management District (SCAQMD) is the air pollution control agency for the urbanized portions of Los Angeles, Riverside and San Bernardino Counties, plus all of Orange County, in Southern California. Its coverage area is only 10,743 square miles, but this geographic area is home to more than 16.8 million people. This is roughly half the population of the entire state. After New York City, this is the second most densely populated area in the United States and it is also one of the smoggiest, due to its population, its dependence upon motor vehicles due to the timing of its period of greatest growth, its industrial base, and its particular climate and topography. The region has been chronically out of compliance with the National Ambient Air Quality Standards (NAAQS).<sup>2</sup>

Our research objective to identify the effects of PCE regulation on the dry-cleaning industry is aided by the fact that the SCAQMD has the authority to impose more stringent air quality rules than those which prevail elsewhere. In the case of perchloroethylene, SCAQMD implemented nearly identical rules to those described above, but did so four years earlier with their Rule 1421. Under this rule, additional dry cleaning machinery added after January 1, 2003 was required to be non-PCE, and all PCE-based dry cleaning facilities were required to install “state-of-the-art” air pollution controls by November 2007.<sup>3</sup> This differential timing of essentially the same increases in regulatory stringency for the SCAQMD area and elsewhere in the state permits us to observe the industry during the pre-2003 period, when the same regulations were in force both inside and outside the SCAQMD. Between 2003 and 2007, the regulations within the SCAQMD were more stringent. Then from 2007 onwards, the rest of the state caught up with the SCAQMD regulations.

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<sup>2</sup>Figure 6 shows the SCAQMD coverage area in the context of one of their daily air quality maps.

<sup>3</sup>One control technology is “dry-to-dry non-vent capture.” These systems have secondary controls that keep as many PCE fumes as possible from escaping into the atmosphere as fugitive emissions.

We anticipate that an increase in regulatory stringency has increased costs for dry-cleaning businesses. Specifically, there are currently three widely used alternative dry-cleaning technologies to PCE, all of which involve a reasonably large fixed cost (\$40,000-\$150,000) for conversion (Ong (2012)). We expect the increased cost may affect a dry-cleaning firm's decision about whether to stay in business at the current location, or move (perhaps to a location where regulations are less stringent) or to shut down and exit the industry. Figure 7 shows trends in dry cleaners' choices over time. There appears to have been an upward trend in instances of dry cleaners exiting the industry during the period. One possible explanation for this trend is the increased cost associated with operating a dry cleaning firm under the new regime of regulation. However, it is essential to distinguish between the effects of new regulations and secular changes in the demand for dry-cleaning services. Over the time period in question, dress codes for business have shifted and fabric technology has also changed. Dry-cleaning firms may go out of business because costs increase due to regulation, or they may go out of business because demand has declined over time so that a "shake-out" in the industry would have been expected even without the increase in regulatory stringency. We do not have sufficient data to attempt an econometric structural model that separately characterizes both the demand and supply functions for this particular industry, so the specifications we employ are, of necessity, reduced form models.

Our empirical models focus upon the impact of regulatory changes on the viability of dry-cleaning businesses, treating each observation as a particular business in a given year. However, implicit in business closures or relocations are the consequences of these decisions for the local communities. It is also important to study the pattern in solvent conversion, closures, and relocation of dry cleaning firms as a result of PCE environmental regulation because there are potential distributional



consequences. If dry cleaners are more likely to close (rather than to incur the high fixed costs of switching solvents) in already disadvantaged areas, this could create a hardship for employees in jobs where dress or uniform requirements dictate dry cleaning services. These workers will find it more difficult to maintain professional wardrobes. However, there is also a benefit to the local community in the form of reduced emissions of PCE from dry cleaners in the area. Clearly, there are winners and losers when dry-cleaning establishments close or relocate. The identities of the affected groups will figure into any assessment of the equity impacts of these regulations.

Has increased stringency in the regulation of PCE in California made it more likely that dry cleaning firms go out of business? Of those firms that exit, are they more likely to be located in lower socioeconomic status or minority neighborhoods? Given that over 40 percent of dry-cleaning enterprises in California are owned by a single ethnic group (i.e. Koreans), have there been any notable differences in closure rates in those instances where there is sufficient information to assign a Korean-versus non-Korean ownership indicator to each business?

A few earlier studies have examined the effects of the CAA on small business industries in the SCAQMD. Thomas (2009) examines the relationship between environmental regulation of chlorinated solvents and economic growth in the metal finishing industry. He compares employment trends in Southern California with those in Chicago and Detroit (traditionally prominent metal finishing areas) to suggest that there were no adverse employment effects of the SCAQMD's regulation on the metal finishing industry beginning in 1988. Thomas and Ong (2004) examine the relationship between environmental regulations and industrial firm location decisions using the wood household furniture industry in Southern California. Using data from the Government Accountability Office, the *Los Angeles Times*, and the Census, they

find that firm location decisions appear not to have been consistent with minimum cost theory and that factors such as agglomeration economies also seem to have influenced firms' decisions to relocate.

There is also a well-developed body of literature examining the effects of environmental regulation on both industry and individual firms. Becker (2011) looks at the spatial heterogeneity of compliance costs. Burton et al. (2011) examine the effects of environmental regulatory compliance costs on the paper and pulp industry structure. Fowlie (2009) discusses environmental leakages, while Millimet et al. (2009) offer a broader review of the environmental regulation literature. Rassier and Earnhart (2011) look at some of the financial impacts of environmental regulation.

The specific research described here belongs to the nascent literature exploring the effects of the PCE regulation on the dry cleaning industry. Thomas (2007) examines how the dry cleaning industry responded to the SCAMQD PCE regulations by adopting alternative technologies. The author conducted fifteen in-person interviews and 187 phone interviews of dry cleaners within the SCAQMD's jurisdiction to determine their attitudes toward Rule 1421. These interviews suggest that while adoption of new technology is occurring, there has been some resistance. Policy recommendations include increasing financial assistance for conversion to alternative dry cleaning technologies and increasing education about the viability of those technologies.

Ong (2012) uses data from SCAQMD to examine the environmental justice impacts of the PCE phaseout in SCAQMD. He finds that dry cleaners in neighborhoods with relatively lower incomes and higher concentrations of minorities are less likely to adopt non-PCE technology. He also found that dry cleaners in the same neighborhoods were less likely to obtain one of SCAQMD's grants to assist in the cost of switching to greener technology. We acquired the same set of data from

SCAQMD. However, the SCAQMD documents only those firms in its own jurisdiction that have ever required permits to operate a dry-cleaning establishment that uses either PCE or hydrocarbon cleaning technologies. Firms that have never used either of these solvents do not appear in the regulatory database from the SCAQMD. While SCAQMD permit application dates are recorded, and the SCAQMD data do indicate whether a particular permit is now inactive, the data fail to record an essential piece of information: the *date* upon which the permit became inactive. Thus the SCAQMD data, alone, do not permit us to reconstruct a retrospective panel of data for each dry-cleaner that relies on each regulated technology in each year.<sup>4</sup> However, we augment these data with a twenty-year unbalanced panel of all dry-cleaning establishments in the state of California from 1990 to 2009, from the National Establishment Time Series. While it is not possible to identify which firms changed to “green” technology at which time, we can examine patterns in the timing of firm closures and correlate these decisions with the degree of regulatory stringency in effect in the relevant jurisdiction at that time.

We contribute to the literature by pooling data from a number of sources to construct a relatively rich set of data that provides more direct measures for our variables of interest. To review, we use NETS data used to build a panel data set for all retail dry-cleaning businesses in California, both inside and outside the SCAQMD coverage area, from 1990-2009.<sup>5</sup> Important explanatory variables include the size of the firm, measured by sales revenue for each establishment (available in the NETS

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<sup>4</sup>There are many different AQMDs across the state of California. We contacted all of the major AQMDs and acquired their regulatory data, but there is no standardization and each district collects different variables. While we had hoped to construct a state-wide database of which firms used which technology over which time-period, this is unfortunately impossible.

<sup>5</sup> Dry cleaners defined as SIC4 code = 7216 and the SCAQMD has regulatory authority over these businesses if they use either PCE or hydrocarbon solvents. See <http://www.aqmd.gov/aqmd/cities.html>.

data), average income and the ethnic and racial mix of the neighborhood where each cleaner operates (with annual series interpolated at the census tract level from the US Census and the American Community Survey), and county-level patterns in economic activity in general, specifically the percentage change since the previous year in the number of employees, the number of establishments, and first-quarter payroll (from the County Business Patterns dataset). We also measure some explanatory variables in a potentially more appropriate way. For example, we use firm-level sales data instead of number of machines (e.g. as used by Ong (2012)) to measure firm size, and we can also use numbers of employees. Finally, we exploit the opportunity to use a difference-in-differences type of identification strategy to estimate the effect of the regulation on dry-cleaning firm closures because we observe similar regulations “stepping in” at different points in time within and outside the jurisdiction of the SCAQMD.

## Data

We combine data from several sources. The first set of data comes from the National Establishment Time Series database, or NETS. The NETS data include twenty years of historical data on over 340 variables for more than 41.7 million U.S. establishments from January 1990 to January 2009. We purchased complete time-series data for all dry-cleaning related SIC/NAICS codes for six states, but we concentrate here on the data for California, and especially for those areas under the jurisdiction of the South Coast Air Quality Management District (SCAQMD). The second set of data employed is from SCAQMD and contains dry cleaning permit information for each regulated machine in each firm, retrospectively for the period of 1957-2011. The third set of data is Census-tract level sociodemographic characteristics from 1990-2000 obtained from the Neighborhood Change Database

(NCDB) prepared by Geolytics, Inc. The fourth set of data is five-year (2005-2009) average of sociodemographic characteristics at the Census tract level from the American Community Survey (ACS) of the U.S. Census Bureau. A fifth data set is the County Business Patterns data ([www.census.gov/econ/cbp](http://www.census.gov/econ/cbp)), which we acquired for the 58 counties of California, annually from 1989 through 2009. Finally, we examine data from the California Air Resources Board on ambient concentrations of perchloroethylene as measured at the eleven California receptors that were in operation in the urban areas of the state continuously during 1990-2009.<sup>6</sup>

### *Description and Manipulation*

The NETS database is a compilation of twenty years of Dun and Bradstreet (D&B) data. A snapshot, reflecting the economic activity of the preceding year, was taken every January. The database is as close to an annual census of American business as exists and allows researchers to focus on detailed components of growth in the U.S. or any geography of interest. Our data provide comprehensive information about all dry-cleaning establishments in California over 20 years. The observation level is the DUNS number.<sup>7</sup> From these data we obtain information on whether the firm is in business, has moved (and to where it moved), and firm revenues. Neumark et al. (2011) use NETS data to examine the differential job creation between large and small firms in the United States. They conducted several tests of the quality of the data and found it to be consistent with other publicly available measures.

The second set of data is from the SCAQMD regulatory agency. Records in the SCAQMD dataset consist of individual machine permit records. Only those

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<sup>6</sup>[www.arb.ca.gov/aqd/aqcdcd/aqcdcdld.htm](http://www.arb.ca.gov/aqd/aqcdcd/aqcdcdld.htm)

<sup>7</sup>The DUNS number is a nine-digit number, issued by D&B, assigned to each business in the D&B database.

machines which use perchloroethylene or hydrocarbon solvents must be regulated, so any dry cleaner in the NETS database that does not appear in the SCAQMD database can be inferred to have never used either of these solvents.<sup>8</sup> These SCAQMD records show the dates a dry cleaner applied for and received permits for a given machine, the particular type of machine being regulated, and perchloroethylene emissions records for those machines. Unfortunately, these data contain permit application and issuance dates, as well as a notation if the permit is currently inactive, but they do not indicate the date when each permit became inactive. This flaw in these data prevents us from pinning down the exact span of years when each machine was operating. We know only when it was placed into service, not when it was taken out of service. However, from the SCAQMD records we obtain information on all of the regulated types of technologies each firm is currently using (i.e. PCE or petroleum), and whether the firm has active permits for regulated dry cleaning technology.

The SCAQMD data also contain owner/manager names, which allows us to infer whether the firm's main decision-maker appears to be Korean. We make use of a comprehensive list of all Korean last names to identify whether firm owners are likely to be of Korean descent. While this categorization is not conclusive, it is important because roughly 40% of dry-cleaning firms in California are Korean-owned and there is an active Korean American Dry Cleaner's Association that raised strong objections to the proposed phase-out of PCE in 2002, in spite of growing concerns about the health effects.<sup>9</sup>

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<sup>8</sup>We have matched the street addresses in the SCAQMD data to the street addresses in the NETS data as fully as possible.

<sup>9</sup> (<http://www.loe.org/shows/segments.html?programID=02-P13-00045&segmentID=4>).

Data on neighborhood sociodemographic characteristics at the Census tract level from 1990-2000 were obtained from the Neighborhood Change Database (NCDB) provided by Geolytics. Information for individual intercensal years between 1991 and 1999 was linearly interpolated using values from 1990 and 2000.<sup>10</sup> These data were spatially normalized by Geolytics to the extent of the 2000 Census tract level definitions. We also gathered information on the same set of sociodemographic variables from the more-recent American Community Survey, which provides five-year (2005-2009) averages at the Census tract level. We associate these averages with 2007, then use information from the 2000 census to interpolate and extrapolate approximations to annual counts for the period from 2001-2009 for each census tract. Thus the interpolated/extrapolated annual data for the sociodemographic characteristics of each neighborhood are rather crude, but this information would seem (a priori) to be an important set of controls for our model.

Each observation in the NETS data set was originally a single firm (DUNS number) with a set of variables describing its history. We manipulated these data to create an unbalanced panel of firm-year observations spanning the years 1990-2009. Using latitude and longitude information for each of the individual firms, we spatially matched each firm with the 2000 Census tract containing it, therefore assigning that tract’s characteristics as each firm’s “neighborhood” characteristics. Finally, by firm, we add the unfortunately limited information from SCAQMD records on type of dry cleaning technology. The SCAQMD information allows us to distinguish only three types of firms: (a) those that have never been regulated by SCAQMD, (b) those that are in business in 2011 but no longer regulated as of the date we acquired the SCAQMD data, and (c) those that are still using PCE in 2011.

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<sup>10</sup>Stata’s “ipolate” command is helpful for this task.

The data from the County Business Patterns (CBP) files of the U.S. Census provide us with county-level data on three important variables: number of employees, number of establishments, and first-quarter payroll. The information is broken down by NAICS/SIC codes, but censored when there are too few observations in a particular industry. We have detailed information on each dry-cleaning firm’s specific sales revenues in each year from the NETS database, so we rely on the CBP data to control for overall business activity in each county in California over the twenty years of our sample. Overall business activity is likely to account for systematic variations in dry cleaning demand, since consumers have the option to have their clothing cleaned less frequently when budgets are tight. The counts and totals provided in the CBP data will reflect the size of each county in the state, so we construct percent changes in each of the three variables as a measure of “recent economic trends” in each county that is independent of the absolute magnitude of each variable in each county.<sup>11</sup>

Our final data source permits us to take a look at the actual effects of efforts to reduce perchloroethylene emissions in California. In 1993, the California Environmental Protection Agency’s Air Resources Board (CARB) adopted the Airborne Toxic Control Measure for Emissions of Perc from Dry Cleaning Operations (Dry Cleaning ATCM), which set down the equipment, operations and maintenance, recordkeeping, and reporting requirements for PCE dry cleaning establishments. In 2003, the Board evaluated the effectiveness of these measures and established that emissions from dry-cleaning establishments had been reduced by approximately 70 percent, but that more could be done. In 2007, the Dry Cleaning ATCM was

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<sup>11</sup>While we have not yet done so, there are certain sectors of the economy for which activity might be a better indicator of dry-cleaning demand than others. For example, activity levels in “Finance and insurance” or “Management of companies and enterprises” might have more bearing on the demand for dry cleaning than “Forestry, fishing, hunting, and Agriculture Support” or “Construction”.



amended to phase out PCE equipment. The CARB maintains a database of air quality measures over time, collected at 907 different monitoring sites throughout California. Not all of these monitors measure PCE concentrations, however. Figure 13 depicts the pattern of years over which PCE data have been collected at 31 different monitors. Only eleven of these monitors have collected PCE data continuously over the period from 1990 to 2009 covered by our analysis. Of these, five are located in the SCAQMD area (or Ventura, adjacent to the SCAQMD area), and six are located elsewhere in the state. We examine the time patterns of PCE concentrations at these eleven receptors to determine the outcomes of PCE regulation over this time period.

### *Summary Statistics*

Table 9 provides a brief summary of the main variables employed in our specifications. The full sample consists of 93,920 observations on up to 20 time-series observations for each of 9,044 different DUNS numbers (owners) of retail dry-cleaning establishments in the state of California. These are unbalanced panel data. Table 10 summarizes descriptive statistics for those dry cleaners under the jurisdiction of SCAQMD and Table 11 describes dry cleaner and neighborhood characteristics for the rest of the state outside of SCAQMD.

As can be seen from Table 9, the average annual sales of dry-cleaners that have closed, as well as those that have moved, are greater than those which continue at the same location in any given year. Establishments that exited were located in slightly poorer neighborhoods, averaging \$67,370 in mean household income, as opposed to the \$72,020 mean household income in the neighborhoods of establishments that have continued to operate in the same location. In addition, there is a slightly larger proportion of Hispanics and non-whites (Asians and others) in communities

where dry-cleaners closed as opposed to continuing to operate. Tables 10 and 11 reflect similar differences between closers and non-closers for just SCAQMD and non-SCAQMD dry cleaning firms.

The data show that nearly 25% of the firms in the stayer group, at least some time in the past, have carried permits for the use of PCE or hydrocarbon technologies. This is true for only 18% of movers and 8% of firms that have closed. Of the firms that have ever carried such permits, 12% of firms that do not move in the current period are Korean-owned. For movers, only 9% are Korean-owned, and for firms that close, the Korean-owned proportion is much smaller, at just 3%.

## Methods

We seek to explain the effect of the PCE regulation on a dry cleaning firm's decision to stay in business at the same location or exit the industry. We model this decision using a difference in difference strategy with year fixed effects.

We assume that each firm has an underlying latent propensity-to-fail variable that, if it could be observed and measured, would simply be regressed upon a vector of explanatory variables in an ordinary least squares framework. Instead, however, this latent propensity is unobserved. When it is large – interpreted as positive – we see a business fail. When it is small, the business does not fail. The scale of the propensity variable is also unobserved, so that the parameters of the latent regression can be estimated only up to a scale factor. These standardized scale parameters are used to calculate the fitted probability of a business failure as a function of specified values of the explanatory variables. Of additional interest are the marginal effects at the means (MEMs) and/or the average marginal effects (AMEs) of each explanatory variable on the probability of a business failure.

Most econometrics textbooks now contain a thorough discussion of the maximum likelihood estimation of binary outcome discrete choice models.<sup>12</sup>(For example, Wooldridge (2002)) We focus on the specification of the index portion of the model that drives the value of  $y_{it}^*$ , which is the latent propensity for firm  $i$  to go out of business in period  $t$  (base year = 1990):

$$y_{it}^* = \beta_0 + \beta_1 SC_i + \sum_{t=1991}^{2008} \gamma_t \mathbf{D}_t + \sum_{t=1991}^{2008} \delta_t SC_i \mathbf{D}_t + \theta' \mathbf{X}_{it} + \varepsilon_{it}$$

where  $SC_i$  is an indicator for the area regulated by the South Coast Air Quality Management District and  $\mathbf{D}_t$  is a vector of year indicators that control for annual differences in the dependent variable between dry cleaning firms in SCAQMD and those in the rest of the state.  $\mathbf{X}_{it}$  is a vector of controls for county business conditions, including percentage changes from the previous period in overall county employment, number of establishments in all sectors, and first-quarter payroll, to proxy for fluctuations in demand for dry-cleaning services. This vector also includes sales data for the dry-cleaning business in question as well as a set of sociodemographic characteristics of the census tract in which the dry-cleaning business is located. This is to control for neighborhood pressure to “go green,” and also for local dependence on cheap and effective dry-cleaning services. The assumption of logistic-distributed errors leads to a maximum likelihood binary logit estimation method.

1990 is our base case year, so the latent regression specification *outside* SCAQMD is:

$$y_{it}^* = \beta_0 + \theta' \mathbf{X}_{it} + \varepsilon_{it}$$

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<sup>12</sup>We also plan a three-alternative outcome variable (stay in business at same address, stay in business but move to a different address, and go out of business). This model is estimated as a multinomial logit choice model, so for consistency we use the binary logit model for the failure model, rather than the usual binary probit model.

Inside SCAQMD, it will be:

$$y_{it}^* = (\beta_0 + \beta_1) + \theta' \mathbf{X}_{it} + \varepsilon_{it}$$

In each subsequent year, namely 1991 through 2008, the latent regression will take the following form for counties outside Southern California:

$$y_{it}^* = (\beta_0 + \gamma_t) + \theta' \mathbf{X}_{it} + \varepsilon_{it}, \quad t = 1991, \dots, 2008$$

Inside California, the propensity to fail will be given by:

$$y_{it}^* = (\beta_0 + \beta_1) + (\gamma_t + \delta_t) + \theta' \mathbf{X}_{it} + \varepsilon_{it}, \quad t = 1991, \dots, 2008^{13}$$

We use the margins command in Stata to calculate the average marginal effect of each year in  $\mathbf{D}_t$  and the average marginal effect of a firm being inside or outside the Southern California counties covered by the South Coast Air Quality Management District (SCAQMD), captured in our model by the indicator variable  $SC_i$ . Our plots show the differential probabilities of business failure, relative to 1990, between firms inside SCAQMD and the rest of the state. The precise estimates plotted for the rest of California, by year, are  $\gamma_t$  for  $t = 1991, \dots, 2008$ , and  $(\gamma_t + \delta_t)$  for  $t = 1991, \dots, 2008$  in Southern California. If dry-cleaning firm failure rates display common trends prior to the main regulatory changes in Southern California, we would expect to find that  $\delta_t = 0$  in these prior years (or, equivalently, that  $\gamma_t = (\gamma_t + \delta_t)$ ). In years when failure rates in the two jurisdictions differ, we look to the sign and statistical

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<sup>13</sup>We drop the year 2009 from the estimating sample because we cannot conclude that firms present in the sample in 2009 do not go out of business before the following year without the evidence of their presence in the sample in that subsequent year.

significance of the  $\delta_t$  parameter. When the tighter regulations were proposed for the SCAQMD region, industry advocates complained that the higher costs imposed on these business would threaten their viability. Our goal is to examine the statistical evidence to determine whether SCAQMD dry-cleaners went out of business at a higher rate than in the rest of the state whenever the regulations there were more stringent than in other areas.

## Results

### *Logit Specifications*

Table 12 displays the results for a succession of increasingly general binomial logit specifications to explain each firm's decision at the end of each year in the data. There are two alternatives: to exit or to not exit. Across these 3 models, we start with just the interactions between the SCAQMD indicator and year fixed effects. Then we included the percent change in county-wide employment, first quarter payroll, and number of establishments. We then include firm sales, employment, and average household income and ethnic and racial mix in the neighborhood. The estimated coefficient of interest is that on the interaction between year and SCAQMD.

Examining the coefficients on the interaction term between year and whether the dry cleaning firm is in SCAQMD for 1996 and 2008, we see that there is actually a lower propensity for dry cleaning firms under the jurisdiction of SCAQMD to exit. These statistically significant and negative results persist in columns 2 and 3, where we add controls for county-wide business pattern changes and census tract level sociodemographic characteristics. A possible explanation for the 2008 result is that dry cleaning firms in SCAQMD are those left in the market after four years of stricter regulation. Those remaining firms had longer to adjust to the new technology

requirement so that when the regulation went into effect for the rest of the state, remaining firms in SCAQMD were relatively less likely to close. When the regulation became binding in the rest of the state in 2007, firms in SCAQMD were not affected as heavily as those in the remainder of the state.

Figure 8 suggests an alternative explanation for the lower propensity of dry cleaners in SCAQMD to close. We see that sales levels, controlling for `emp_nets`, and all the CBP variables and sociodemographics, are systematically higher for facilities in SCAQMD than elsewhere in CA, except maybe in 2001 and perhaps in 2008. But not in individual years, just overall. The higher sales in SC may have permitted those firms to stay in business. Finally, Figure 9 shows that dry cleaners owned by Koreans are, as a group, systematically less likely to close. Since nearly half of all dry cleaners within SCAQMD are Korean owned, this is another possible explanation for why they are less likely to close. (Thomas (2007))

We have determined that failure rates for dry-cleaning businesses in California during the period from 1991 to 2009 have tended to exceed the 1990 rate in all subsequent years except perhaps in 1994, and possibly in 2008, for establishments in the SCAQMD area. Figure 10 shows that controlling for (a) facility sales and number of employees, (b) county-level business conditions, and (c) the neighborhood income and sociodemographic mix around the establishment, failure rates for dry-cleaning businesses in the SCAQMD region have actually been lower than those in the rest of California in every year except 1991. Failure rates in all jurisdictions declined until 1994, when new national requirements for PCE were announced, whereupon failure rates increased sharply over the next couple of years and remained fairly high until 2000-2001, when they appeared to decline until 2003. Then failure rates rose in both SCAQMD and non-SCAQMD areas until 2005 and then dropped noticeably in 2006. At the end of our sample, in 2008, the first year of the recession, failure rates

appear to begin to rise in the rest of California, while they continue to decline in the SCAQMD area. The lower failure rates in the SCAQMD area are not explained by the higher levels of demand in those areas, since we control for sales and county-level employment, establishments, and first-quarter payroll.

Table 13 shows results from a binomial logit model for which we define a variable *treated*. It takes on a value of 1 for years 2003 and later in SCAQMD and for years 2007 and later in the rest of the state outside SCAQMD, and a value of zero otherwise. The first column shows that, on average, firms are less likely to exit if they are being regulated and if they are inside SCAQMD. The second column controls for county level macroeconomic conditions. We see no substantive change in the differential effect of being regulated between those dry cleaners in SCAQMD and those outside of it. The final column explores further the environmental justice angle. Firms in neighborhoods with a higher proportion of blacks inside SCAQMD are more likely to exit, but the effect is smaller than for those dry cleaners not in SCAQMD. On the other hand, dry cleaners located in neighborhood with a higher proportion of Asian and other races are also more likely to exit, and this time the effect is larger for dry cleaners inside SCAQMD than in the rest of California.

Thus we have uncovered little evidence that dry-cleaning businesses in Southern California suffered more than similar businesses in the rest of the state as a consequence of the more stringent regulation they faced during 2003-2007. The flip side of the coin is whether regulation of PCE was less effective in the SCAQMD area than elsewhere in the State over these time periods. The next section addresses that question.

*What has happened to ambient PCE levels in California?*

Using data for the eleven air quality monitors in California that have continuously recorded PCE concentrations annually since 1990, we can plot the time profiles of average PCE concentrations at each monitor. Within a rough scatter of points that depict the longitude and latitude for every official air quality monitor over this time period in California, Figure 12 shows the relative distribution of those monitors that can provide a continuous time-series of PCE measures. We have grouped the annual data for these eleven monitors into “SCAQMD plus Ventura” and “Other non-SCAQMD” monitors and show the decline in PCE levels over these two decades in Figures 14 and 15. Clearly, there have been substantial reductions in PCE over time at all monitors, although levels are considerably higher in the SCAQMD region. There are just a couple of anomalous points in these data.

We pool all of the data for these eleven monitors over twenty years in a panel dataset and use regression method to summarize the time-trend in concentrations of PCE and the differential between the SCAQMD region and the other monitors. Regression results for the logarithms of the average, median, 90th percentiles and 75th percentiles of the distribution of PCE levels during the year, at each monitor, are shown in Table 14. These regressions confirm that PCE levels started at a significantly higher level in the SCAQMD area than elsewhere. They have been declining over the period in question, and at two to three percent more per year in the SCAQMD than elsewhere in California. The results are almost identical if we allow for monitor-level fixed effects.

Dry-cleaners are not the sole users of PCE, so the change in total levels of PCE do not confirm that dry-cleaners have reduced their emissions of PCE by this percentage overall or by a greater percentage than dry-cleaners elsewhere. However,



there is no evidence to suggest that the somewhat lower failure rate for dry-cleaners in the SCAQMD area has led to higher levels of fugitive PCE emissions in that region. According to Figure 8, nominal sales of dry-cleaning establishments in the SCAQMD area in 2001 dipped towards those in the rest of the state, after controlling for number of employees, neighborhood incomes and sociodemographic characteristics as well as county-level economic conditions (total employees, total establishments, and first-quarter profits). In all other years since 1990, nominal sales for the SCAQMD region have been higher than elsewhere, although the differences in individual years are not statistically significant.

What might account for the greater survival rates of dry-cleaners in the SCAQMD area, despite the more stringent regulations there during 2003-2007? We do not have comprehensive data on take-up rates for subsidies for the replacement of equipment with green technologies. It could be the case that these take-up rates in the SCAQMD area were high enough to prevent business failures that would otherwise have occurred.

A final consideration is whether dry-cleaners go out of business only to be replaced by other similar businesses at the same location. In this paper, we have treated the panel as a set of unique DUNS numbers followed over time. We could alternatively have defined the unit of observation as a set of addresses over time, where there is an observation for every address ever appearing in the NETS dataset and an indicator for whether there is a dry-cleaning establishment operating at that site in each year. Figure 11 shows a plot of the simple count of total numbers of dry-cleaning establishments in the SCAQMD area and outside. As can be seen, there are more total drycleaners serving the SCAQMD area than in all of the rest of California. For the most part, the time patterns in the counts of establishments in business in each year (subsuming both births and deaths of establishments) follows

essentially the same pattern in both jurisdictions. We highlight the years 1994, 2003 and 2007 in these plots.

## Conclusions

The purpose of this study was to examine some of the possible effects of the differential PCE regulations over time on the dry cleaning industry within California. We construct a detailed data set that includes a number of explanatory variables that have not previously been examined in this literature. Our primary covariates are the interactions between year fixed effects and an indicator for the South Coast Air Quality Management District (SCAQMD), where tighter regulations came on line three years sooner than in the rest of the state of California. We concentrate on factors that have a systematic effect on the propensity for a dry cleaning establishment to close.

Three questions motivated our study:

1. Has increased stringency in the regulation of PCE in California made it more likely that dry cleaning firms exit?

Our data do not contain any information on dry-cleaning establishments prior to 1990, which corresponds to the point when PCE was identified as a toxic air pollutant in the Clean Air Act Amendments. Thus we cannot establish the prevailing pattern of dry cleaning business exits prior to the year when it became apparent that more regulation was forthcoming. However, our data suggest that exit rates exceeded rates in 1990 in almost every subsequent year. A few notable exceptions include years leading up to 1994 (when regulations were tightened by the California Air Resource Board), 2003 (when

the regulations were tightened again), and from 2006 through 2008, although exit rates exceeded 1990 rates again outside the SCAQMD district by 2008.

If the new regulations had come as a surprise in each of 1994, 2003 and 2007, one might have expected increases in business exits. However, plenty of notice was given of the impending changes in rules, and it is possible that firms which were destined to exit because of the changes in rules actually exited over a wider span of time leading up to the rule changes, so that few vulnerable firms were left by the time the rule changes actually took effect. Exits may “lead” rule changes, rather than coincide with them.

2. Of those firms that exit, are they more likely to be located in lower socioeconomic status or minority neighborhoods?

The negative sign on the household income variable in our model to explain the propensity for a dry-cleaning firm to exit tells us that dry cleaning firms are more likely to exit in neighborhoods which are lower income. The probability of exit also appears to be greater in non-white neighborhoods. The effect is not statistically significant in Hispanic areas. The effect of Asian/other ethnicities is about twice as great as the effect of black populations.

Overall, dry cleaning establishments do not appear to be located disproportionately in minority neighborhoods compared to the proportions of the population in the black and Hispanic categories. In California as a whole, the population recorded in the American Community Survey is roughly 6.1% black, and the percentage black in the neighborhoods of all dry-cleaners in California over our full sample is 6.2. In our sample, the average percentage of Hispanics in the neighborhoods of dry cleaners is about 25%, but the overall proportion of

Hispanics in California's population is now roughly 37%. Thus dry-cleaning establishments are proportionately under-provided in Hispanic communities, compared to the overall population. While the proportion of Hispanics in the SCAQMD proportion of the sample reaches about 30%, the proportions of Hispanics in Los Angeles, Orange and San Bernardino counties are 47%, 33% and 48%, respectively. Notably, the overall proportion of persons of Korean race/ethnicity in California is only 1.2%, although the numbers run as high as 2.8% in Orange County. It is not possible to sort out the Asian ethnicites from others, given the lack of specificity in the 1990 census designations.

Thus the result that dry-cleaners are more likely to close in areas with higher proportions of blacks and Asian/other ethnicities is notable. If dry-cleaning establishments had occurred with greater frequency in neighborhoods that were more black or more Hispanic in their populations, concerns about "environmental justice" in terms of exposure to PCE would certainly be raised, but this does not appear to be the case in our data. Instead, the regulation of this industry appears to have resulted in a decrease in services to these communities. It is possible that many of these neighborhoods have been in transition over time. Dry cleaners in communities with growing demands for dry-cleaning services might foresee sufficient future profits to justify the large capital expenditures required for conversion to green cleaning technologies. Those which did not foresee sufficiently strong future demand might have decided instead simply to exit. (Current firm sales, however, seem to have had little independent effect upon exit decisions, so this is merely speculative.)

3. Given that over 40 percent of dry-cleaning enterprises in California are owned by a single ethnic group (i.e. Koreans), have there been any notable differences

in exit rates in those instances where there is sufficient information to assign a Korean- versus non-Korean ownership indicator to each business?

Of those dry-cleaning firms located within SCAQMD, being Korean owned is associated with a systematically lower propensity of closing.

Finally, using PCE monitor data we find that ambient PCE concentration has decreased over the past 20 years, and it does not appear that dry cleaners going out of business is the cause. We are considering possible future extensions, as well. Some prospective directions for future research include:

1. Make annual requests for SCAQMD data. These data are collected to provide a snapshot of the current status of all regulated facilities, rather than to facilitate construction of historical panel data. If we request the data on an annual basis, we can build true panel data based on these snapshots going forward. In particular, it will be possible to track the years when specific permits became inactive—an important piece of information not retained in the SCAQMD’s current spreadsheets. The PCE rules will become progressively more binding until 2023, when all PCE-using equipment must be retired.
2. Explore other events for dry-cleaning firms. In this study, we have concentrated upon firm deaths (exits). There is also some potential to consider the decision to move (e.g. how many firms moved from inside the SCAQMD regulation area to outside that area). We also observe that while discontinued DUNS numbers in dry-cleaning imply that businesses have closed, we also see that the total number of dry-cleaning establishments in California, both within the SCAQMD area and outside, have tended to increase over time. The exceptions have been the period between 1997 and 2000, and perhaps between 2008-2009.

Thus it may be relevant to consider the determinants of firm births. We could consider every location where a dry-cleaning firm is eventually observed and use local neighborhood characteristics and county-level business conditions in a discrete-time event study of firm births.

3. Consider the vintage of the firm's technology. Within the jurisdiction of the SCAQMD, it may be possible to establish the vintage of each piece of regulated dry-cleaning equipment at each establishment. There may be a greater chance of exit corresponding to years in which some piece of PCE-using equipment reaches 15 years of age, the point at which the equipment will need to be retired.
4. Seek detailed information on SCAQMD's financial incentives program for conversion to green technologies. According to Ong (2012), SCAQMD offered financial incentive for conversion and gave establishments in EJ neighborhoods priority in applying for these grants. Despite the pro-environmental justice focus of these grants, the take-up rate for dry cleaners in low-income and minority areas was less than in other areas. (Ong has 2002-2006 permit data with information on 343 grants.) Our findings suggest that even with the subsidy for conversion to green technologies, dry cleaners in "environmental justice" neighborhoods were relatively more likely to close than those elsewhere, thus depriving these communities of the convenience of a neighborhood dry cleaner unless these businesses are merely sold.
5. As an extension and separate paper, learn as much as we can about the dry cleaners located in close proximity to each of the pollution monitors that measure concentrations of PCE. The objective would be to explore whether the regulation reduced concentrations of PCE.

6. To examine the effect of regulation on exits from a slightly different vantage point, create a dependent variable defined as the number of exits at the Census tract level. Examine how our set of regressors affected the number of exits in each Census tract.
7. Further analysis of the SCAQMD sample: It may be possible to analyze the huge spike in the installation of “dry to dry” ventilation systems, intended to keep PCE contained. We know when they applied for and received these permits.
8. Compare NETS data for California to the analogous data for Arizona and Oregon, Massachusetts, Illinois and New York states. We have not had as much success in gathering agency-level data on PCE-regulated equipment for all of these other jurisdictions, but it will be possible to analyze the NETS data, along with the County Business Patterns and Neighborhood Change Database/American Community Survey data for these other states, where regulation has been somewhat different than in California.

# APPENDIX A

## CHAPTER II TABLES AND FIGURES

TABLE 1. Descriptive Statistics (240 respondents, 2 choice sets each)

Variable	Definition	N	Mean	Std. Dev.	Min.	Max.
<i>By choice set:</i>						
pounds ( $q_i^j$ )	package weight	480	2.24	0.567	1.5	3
total price	conventional product	480	5.88	1.87	2.68	10.47
	free-range product	480	7.14	2.46	2.84	15.57
	humanely raised product	480	8.61	2.94	3.13	18.27
price per pound	conventional product	480	2.63	0.48	1.79	3.49
	free-range product	480	3.20	0.71	1.84	5.19
	humanely raised product	480	3.86	0.88	1.94	6.09
<i>Across respondents:</i>						
1(female)	=1 if female	240	0.652	-	-	-
household size <sup>a</sup>	including respondent	236	2.71	1.32	1	8
1(college grad)	=1 if college grad	240	0.402	-	-	-
conservatism	approx. linear rating <sup>b</sup>	240	3.61	1.56	1	7
H. healthiness*	"	240	5.38	1.29	1	7
H. improves well-being*	"	240	5.20	1.78	1	7
antibiotic concerns <sup>a</sup>	"	199	3.86	2.23	1	7

\*H = humanely raised product

<sup>a</sup> A handful of subjects did not answer the household size question; the question about antibiotic concerns was a late addition. Indicator variables are used to control for missing values, and slopes are conditional on data being available.

<sup>b</sup> We cannot statistically reject assumptions that these ratings enter linearly, so they will be treated as continuous variables, to control the size of the parameter space.



TABLE 2. Simple Model, Homogeneous Preferences (240 respondents, 480 choices)

Variable		Coefficients		
-(total price)		$(\beta_Y)$ 0.4282*** (0.0727)		
	1(Conventional) base coefficient	1(Free-range) differential	1(Humane) differential	
pounds ( $q_i^j$ )	$(\beta_C)$ 2.368*** (0.288)	$(\delta_F)$ 0.1066 (0.071)	$(\delta_H)$ 0.2464** (0.101)	
Log L		-541.578		

<sup>a</sup> Asymptotic standard errors in parentheses (\*\*\*significant at the 1% level, \*\*significant at the 5% level). Coefficients arrayed to emphasize baseline marginal utility and differentials for free-range and humanely raised products, to be generalized in Table 3. Parameter estimates in these two models are produced by Stata's clogit algorithm, with errors clustered on the respondent identifier.

TABLE 3. Parsimonious Model, Heterogeneous Preferences (240 respondents, 480 choices)

Variable		Coefficients <sup>a</sup>		
-(total price)	$(\beta_Y)$	0.4927*** (0.102)		
-(total price) × 1(female)		0.1691** (0.079)		
		1(Conventional) base coefficient	1(Free-range) differential	1(Humane) differential
pounds ( $q_i^j$ )	$(\beta_C)$	10.7029*** (0.560)	$(\delta_F)$ -0.0760 (0.502)	$(\delta_H)$ -1.4942** (0.712)
× household size		-0.2479*** (0.093)	-0.1108** (0.056)	-0.1278* (0.069)
× 1(college grad)		-0.8934** (0.362)	0.2566* (0.146)	0.2930* (0.164)
× conservatism		-	-0.0855* (0.047)	-0.1194* (0.061)
× H. healthiness		-		0.1606** (0.068)
× H. improves well-being		-	0.1719*** (0.038)	0.1615*** (0.056)
× antibiotic concerns		-	0.1670*** (0.039)	0.1988*** (0.052)
Log L			-436.718	

<sup>a</sup> Asymptotic standard errors in parentheses (\*\*\*significant at the 1% level, \*\*significant at the 5% level, \*significant at the 10% level). Coefficients arrayed to emphasize baseline marginal utility and differentials for free-range and humanely raised products. Parameter estimates are produced by Stata's clogit algorithm, with errors clustered on the respondent identifier. Note that panel data methods are unnecessary because the explanatory variables are either fixed or randomized, and therefore do not covary with any individual heterogeneity, observed or unobserved. Model also includes unreported incidental parameters on indicators for the availability of data on “household size” for all three product types and on “antibiotic concerns” for the free-range and humanely raised products.

TABLE 4. Derivatives of marginal WTP premium for humane product

<i>With respect to:</i>	<i>For Females:</i>	<i>For Males:</i>
household size (# of persons)	-\$0.19 (-\$0.42, \$0.01)	-\$0.25 (-\$0.62, -\$0.02)
1(college grad) (0,1)	\$0.45 (-\$0.04, \$1.05)	\$0.61 (-\$0.05, \$1.49)
conservatism (1 to 7)	-\$0.18 (-\$0.36, \$0.00)	-\$0.24 (-\$0.53, \$0.00)
H. healthiness (1 to 7)	\$0.24 (\$0.04, \$0.47)	\$0.33 (\$0.05, \$0.73)
H. improves well-being (1 to 7)	\$0.25 (\$0.06, \$0.43)	\$0.33 (\$0.08, \$0.70)
antibiotic concerns (1 to 7)	\$0.30 (\$0.15, \$0.47)	\$0.41 (\$0.20, \$0.74)

We report medians and 2.5<sup>th</sup> and 97.5<sup>th</sup> percentiles of the distribution of the calculated derivative, based on 1000 draws from the assumed joint normally distributed maximum likelihood parameter estimates. Intervals thus reflect the precision of parameter estimates. For full results, see Appendix Table D-1.

TABLE 5. Two-Class Latent Class Model (240 respondents, 480 choices)

Variable	Preference Classes	
	<i>Class 1</i>	<i>Class 2</i>
-(Total price)	0.240*** (0.0742)	0.175* (0.0983)
pounds ( $q_i^j$ )	1.31*** (0.234)	1.48*** (0.294)
... × free-range	0.385*** (0.100)	-0.510*** (0.142)
... × humanely raised	0.430*** (0.143)	-0.646*** (0.187)
Variable	Class separation index (propensity to be in Class 2)	
constant	12.7 (8.99)	
household size	1.17* (0.686)	
conservatism	0.212 (0.303)	
H. improves well-being	-1.34* (0.711)	
antibiotic concerns	-1.64 (1.05)	
<i>Incidental (Non-missing value indicators)</i>		
have(household size)	-10.5 (7.06)	
have(antibiotics concerns)	5.50* (3.25)	
Max Log L	535.52	
asymptotic standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1		

Figure 1 - One example of a choice set

- If every product in a choice scenario seems too expensive, choose “None.”
- If you would look for something else instead, choose “None.”
- If you never buy the meat product(s) being described, choose “None.”

### Choice Scenario #1 (Chicken Breasts)

Suppose you have come to your usual food store. You are considering whether to buy a 1.5-pound package of chicken breasts. The store offers three brands of chicken breasts that look the same. The color, size and fat content of each brand are very similar. The only visible difference is that one brand is marked “Conventional,” one brand is marked “Free-range,” and the third brand is marked “Humane.” The prices are also different.

Keeping in mind your household budget, which would you choose? (check ONE)

	A	B	C	None
Type	Conventional	Free-range	Humane	
Package size	1.5 lbs	1.5 lbs	1.5 lbs	
Price	\$ 3.09/lb	\$ 4.09/lb	\$4.84/lb	
Total cost	\$4.63	\$ 6.14	\$ 7.26	\$ 0
I prefer:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

# APPENDIX B

## CHAPTER III TABLES AND FIGURES

TABLE 6. Descriptive Statistics (N=6795)

Variable	Mean	Std. Dev.	Min.	Max
<b>Dependent variable: Proportion Yes on Prop 21:</b>				
yes/(yes+no)	0.429	0.11	0.09	0.843
<b>1. Gross price of Prop 21:</b>				
Price (=\$18 × veh/hhld)	43.60	11.25	2.05	223.89
<b>2. Median household income:</b>				
Median tract household income	65,212	29,889	11,148	226,509
<b>3. Political ideologies (gubernatorial vote shares):</b>				
Dem. gov vote share (omitted category)	0.576	0.17	0.152	0.953
Green gov vote share	0.014	0.006	0	0.072
Peace/Free. gov vote share	0.012	0.011	0	0.109
Rep. gov vote share	0.368	0.167	0.015	0.807
Libert. gov vote share	0.015	0.007	0	0.099
Am. Indep. gov vote share	0.017	0.01	0	0.088
<b>4. Environmental preferences:</b>				
Share hybrid vehicles in tract	0.003	0.002	0	0.046
Share pickups in tract	0.094	0.079	0.005	1.024
Mean(vehicle age)	3.629	1.17	0.137	21.373
Var(vehicle age)	0.117	0.419	0	13.57
Nominal congress LCV score	58.13	42.755	0	100
<b>5. Government fiscal responsibility:</b>				
Bond rating data available	0.799			
1(Some lower-rated muni. bonds)	0.435			
<b>6. Salience of state parks:</b>				
Distance from tract to nearest park (miles)	7.157	6.751	0	90.596
Size of nearest park (square miles)	6.086	31.736	0	933.817
Size of tract (small=urban)	0.551	4.14	0.001	206.956

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**Table 6. – continued from previous page**

Variable	Mean	Std. Dev.	Min.	Max
Fishing licenses/hhld	0.086	0.068	0.005	0.664
Hunting licenses/hhld	0.019	0.029	0	0.473
<b>7. Substitutes (counts w/in 20 km):</b>				
Local parks	160.911	120.572	0	455
Local historical sites	6.607	7.162	0	34
State parks (not beaches)	1.01	1.296	0	6
State beaches	1.016	1.745	0	10
State historical sites	0.635	0.837	0	8
National parks	0.001	0.027	0	1
National seashores	0	0.021	0	1
National recreation areas	0.042	0.201	0	1
Museums	12.029	12.825	0	43
Attractions (theme parks, etc.)	21.629	32.101	0	121
<b>8. Ecological regions:</b>				
Central Basin and Range	0.001			
Sonoran Desert	0.016			
Cascades	0			
E. Cascades Slopes/Foothills	0.001			
<b>9. Other sociodemographic controls:</b>				
Median housing value	2.937	1.669	0.345	20.51
High-cost loans per 1000	0.036	0.054	0	1.778
Share of single mother households	0.109	0.075	0	0.679
Farm/fish/forestry	0.015	0.05	0	0.589
Constr/extract/mainten	0.093	0.056	0	0.425
Product/transp/materialmoving	0.117	0.081	0	0.594
Sales/office	0.252	0.061	0.03	0.562
Services	0.174	0.079	0	0.635
Agric/forestry/mining	0.023	0.061	0	0.615
Arts/ent/recre/accom/food	0.091	0.052	0	0.564
Construction	0.076	0.047	0	0.378
Inf/fin/ins/re/rent/lease	0.099	0.055	0	0.439
Manufacturing	0.106	0.063	0	0.458
Prof/scient/mgt/admin/wastemgt	0.119	0.056	0	0.404
Retail trade	0.11	0.041	0	0.371
Transp/warehous/utilities	0.047	0.031	0	0.257
Under 5 years	0.073	0.03	0	0.211
5 to 9 years	0.067	0.026	0	0.17
10 to 14 years	0.072	0.027	0	0.196
15 to 19 years	0.072	0.035	0	0.705
20 to 24 years	0.07	0.042	0.002	0.66
25 to 49 years	0.364	0.073	0.052	0.805
50 to 64 years	0.169	0.054	0	0.432

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**Table 6. – continued from previous page**

<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max</b>
65 to 69 years	0.033	0.018	0	0.156
70 to 74 years	0.026	0.016	0	0.162
75 years and over	0.055	0.039	0	0.451
White (omitted category)	0.62	0.21	0	1
Asian	0.121	0.144	0	0.927
Black/AfricanAmerican	0.061	0.103	0	0.941
Hispanic/Latino	0.355	0.266	0	1
Hawaiian/Pac.Island	0.004	0.01	0	0.144
Other race	0.153	0.144	0	0.803
Multiracial	0.034	0.024	0	0.212

NOTE: There are 5 omitted industries (Armed Forces, Education/Health Care, Public Administration, Wholesale, and Other) and 2 omitted occupations (Armed Forces and management/professionals)



TABLE 7. Main Results

Variables	(1a) Log-odds (clustered on counties)	(1b) Marginals (at the means)	(2) Log-odds (not clustered)	(3) Log-odds SARAR(1,1) model
<b>1. Gross price of Prop 21:</b>				
price (=18×veh/hhld)	-0.00400** (-2.01)	-0.00253*** (-5.03)	-0.00400*** (-4.88)	-0.00331*** (-4.15)
...× (Grn. gov vote share)	-0.241*** (-3.39)		-0.241*** (-6.63)	-0.150*** (-4.54)
...× (Peace/Free. gov vote share)	0.0785 (1.60)		0.0785*** (4.66)	0.0385** (2.85)
...× (Rep. gov vote share)	0.00754*** (3.93)		0.00754*** (4.69)	0.00362** (2.35)
...× (Libert. gov vote share)	0.0485 (0.98)		0.0485 (1.31)	0.0242 (0.70)
...× (Am. Indep. gov vote share)	0.0192 (0.55)		0.0192 (0.79)	0.0514** (2.32)
<b>2. Median household income:</b>				
log(inc) (=log(med.income/10000))	0.0533 (0.68)	-0.0406* (-1.93)	0.0533** (2.10)	0.0107 (0.45)
...× (Green gov vote share)	2.673 (1.61)		2.673*** (2.78)	1.479* (1.71)
...× (Peace/Free. gov vote share)	-6.901*** (-6.32)		-6.901*** (-8.68)	-6.730*** (-9.37)
...× (Rep. gov vote share)	-0.0783 (-0.76)		-0.0783* (-1.81)	-0.0333 (-0.83)
...× (Libert. gov vote share)	-8.851*** (-4.22)		-8.851*** (-9.55)	-6.217*** (-7.39)
...× (Am. Indep. gov vote share)	1.285 (1.35)		1.285* (1.79)	0.452 (0.71)
<b>3. Political ideologies (gubernatorial vote shares):</b>				
Dem. gov vote share (omitted category)				
Green gov vote share	16.530*** (4.35)	4.657*** (4.46)	16.530*** (9.10)	11.200*** (6.77)
Peace/Free. gov vote share	-17.660*** (-5.32)	-10.742*** (-6.86)	-17.660*** (-15.74)	-15.140*** (-14.24)
Rep. gov vote share	-2.668*** (-20.21)	-2.299*** (-20.84)	-2.668*** (-33.54)	-2.294*** (-29.14)
Libert. gov vote share	-9.625*** (-4.12)	-2.861*** (-3.18)	-9.625*** (-5.32)	-4.946*** (-2.96)
Am. Indep. gov vote share	-7.796*** (-4.10)	-7.635*** (-8.06)	-7.796*** (-5.97)	-9.653*** (-8.21)

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Table 7. – continued from previous page

Variables	(1) Log-odds (clustered on counties)	Marginals (at the means)	(2) Log-odds (not clustered)	(3) Log-odds SARAR(1,1) model
<b>4. Environmental preferences:</b>				
Share hybrid vehicles in tract	12.95*** (4.60)		12.95*** (7.34)	12.56*** (7.91)
Share pickups in tract	0.0205 (0.17)		0.0205 (0.34)	0.0146 (0.27)
Mean(vehicle age)	0.00625 (1.08)	0.006 (1.02)	0.00625** (2.13)	-0.0105*** (-3.58)
Var(vehicle age)	0.0683*** (2.80)	0.0554*** (2.75)	0.0683*** (4.10)	0.0837*** (3.69)
Mean(vehicle age) × Var(vehicle age)	-0.00354*** (-2.77)		-0.00354*** (-3.86)	-0.00330*** (-2.72)
Nominal congress LCV score	-0.000133 (-0.59)		-0.000133* (-1.81)	-0.000295*** (-3.52)
<b>5. Government fiscal responsibility:</b>				
Bond rating data available	0.00065 (0.04)		0.00065 (0.10)	0.00772 (1.09)
1(Some lower-rated muni. bonds)	-0.0127 (-1.06)		-0.0127** (-2.43)	-0.0254*** (-4.61)
<b>6. Salience of state parks:</b>				
Distance from tract to nearest park (miles)	-0.00503*** (-4.81)		-0.00503*** (-11.43)	-0.00429*** (-9.01)
Size of nearest park (square miles)	0.000162 (1.56)		0.000162** (2.31)	0.00683*** (2.84)
Size of census tract (small=urban)	-0.00127* (-1.91)		-0.00127** (-2.197)	-0.00180*** (-3.55)
Fishing licenses/hh	0.231 (0.68)		0.231*** (2.61)	-0.0383 (-0.41)
Hunting licenses/hh	-1.533** (-2.238)		-1.533*** (-8.23)	-0.911*** (-5.12)
<b>7. Substitutes (w/in 20 km):</b>				
Local parks	-0.000173* (-1.85)		-0.000173*** (-5.89)	0.000427*** (10.46)
Local historical sites	0.00540** (2.57)		0.00540*** (7.39)	0.00244*** (2.99)
State parks (not beaches)	-0.0253** (-2.89)		-0.0253*** (-9.72)	-0.0352*** (-11.58)
State beaches	0.0142*** (2.86)		0.0142*** (7.87)	0.00787*** (3.55)
State historical sites	0.0218** (2.31)		0.0218*** (7.11)	-0.00189 (-0.55)
National parks	-0.115* (-1.81)		-0.115 (-1.48)	-0.115* (-1.71)
National seashores	-0.234*** (-3.56)		-0.234** (-2.12)	-0.234** (-2.45)
National recreation areas	-0.0877*** (-3.04)		-0.0877*** (-6.48)	-0.0885*** (-5.80)
Museums	0.00321** (2.53)		0.00321*** (6.34)	0.00136*** (2.90)
Attractions (theme parks, etc.)	-0.00346*** (-7.09)		-0.00346*** (-21.31)	-0.00236*** (-13.89)

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Table 7. – continued from previous page

Variables	(1) Log-odds (clustered on counties)	Marginals (at the means)	(2) Log-odds (not clustered)	(3) Log-odds SARAR(1,1) model
<b>8. Ecological regions:</b>				
7 other regions (omitted categories)				
Central Basin and Range	0.160* (1.88)		0.160** (2.34)	0.150** (2.48)
Sonoran Desert	-0.107* (-1.91)		-0.107*** (-5.58)	-0.155*** (-6.42)
Cascades	0.189*** (2.99)		0.189 (1.10)	0.271* (1.83)
E. Cascades Slopes/Foothills	0.405*** (4.33)		0.405*** (6.06)	0.347*** (5.93)
<b>9. Other sociodemographic controls:</b>				
Median housing value	0.0201*** (5.60)		0.0201*** (8.36)	0.0184*** (8.30)
High-cost loans per 1000	-0.116** (-2.03)		-0.116*** (-2.59)	-0.115*** (-2.92)
Share of single mother households	0.143*** (3.80)		0.143*** (3.40)	0.0568 (1.58)
Farm/fish/forestry	-0.228 (-0.92)		-0.228 (-1.52)	-0.0432 (-0.32)
Constr/extract/mainten	-0.489*** (-4.82)		-0.489*** (-6.21)	-0.430*** (-6.36)
Product/transp/materialmoving	-0.482*** (-5.40)		-0.482*** (-8.43)	-0.318*** (-6.19)
Sales/office	-0.415*** (-7.28)		-0.415*** (-8.35)	-0.290*** (-6.69)
Services	-0.158* (-1.84)		-0.158*** (-3.24)	-0.128*** (-2.95)
Agric/forestry/mining	-0.179 (-0.91)		-0.179 (-1.39)	-0.436*** (-3.70)
Arts/ent/recre/accom/food	0.252*** (3.78)		0.252*** (4.45)	0.263*** (4.65)
Construction	0.265** (2.57)		0.265*** (3.27)	0.271*** (3.86)
Inf/fin/ins/re/rent/lease	-0.117 (-1.29)		-0.117** (-1.99)	0.0468 (0.90)
Manufacturing	0.173 (1.35)		0.173*** (3.30)	-0.0806* (-1.72)
Prof/scient/mgt/admin/wastemgt	0.279*** (4.00)		0.279*** (5.19)	0.174*** (3.61)
Retail trade	0.0757 (1.09)		0.0757 (1.18)	-0.0499 (-0.91)
Transp/warehous/utilities	-0.446*** (-2.72)		-0.446*** (-5.19)	-0.388*** (-5.152)
Under 5 years	-0.172 (-1.22)		-0.172* (-1.76)	-0.254*** (-2.99)
5 to 9 years	-0.403** (-2.60)		-0.403*** (-3.58)	-0.502*** (-5.16)
10 to 14 years	-0.490** (-2.52)		-0.490*** (-4.57)	-0.486*** (-5.19)
15 to 19 years	-0.107 (-1.06)		-0.107 (-1.50)	-0.135** (-2.19)
20 to 24 years	0.306** (2.13)		0.306*** (4.54)	0.219*** (3.50)
25 to 49 years (omitted category)				

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Table 7. – continued from previous page

Variables	(1) Log-odds (clustered on counties)	Marginals (at the means)	(2) Log-odds (not clustered)	(3) Log-odds SARAR(1,1) model
50 to 64 years	-0.228*** (-3.22)		-0.228*** (-3.53)	-0.160** (-2.81)
65 to 69 years	-0.360 (-1.65)		-0.360** (-2.36)	-0.275** (-2.11)
70 to 74 years	-0.339* (-1.67)		-0.339* (-1.96)	-0.328** (-2.21)
75 years and over	-0.294*** (-3.82)		-0.294*** (-3.99)	-0.352*** (-5.49)
White (omitted category)				
Asian	-0.360*** (-5.87)		-0.360*** (-17.34)	-0.265*** (-11.70)
Black/AfricanAmerican	-0.995*** (-11.27)		-0.995*** (-31.79)	-0.841*** (-26.72)
Hispanic/Latino	-0.0910 (-1.16)	-0.2178** (-4.09)	-0.0910** (-2.56)	-0.0681** (-1.98)
... × log(inc)	0.241** (2.53)		0.241*** (7.01)	0.220*** (7.06)
Hawaiian/Pac.Island	-0.0679 (-0.19)		-0.0679 (-0.32)	-0.257 (-1.38)
Other race	-0.124*** (-2.15)		-0.124*** (-4.02)	-0.0850*** (-2.75)
Multiracial	-0.0946 (-0.73)		-0.0946 (-1.00)	-0.140* (-1.68)
Constant	1.449*** (13.68)		1.449*** (25.81)	1.373*** (25.20)
<b>Parameters, SARAR(1,1):</b>				
$\lambda$	-		-	4.03e-05*** (15.14)
$\rho$	-		-	0.000712*** (71.80)
$\sigma^2$	-		-	0.0216*** (58.29)
Observations	6795		6795	6795
R-squared	0.869		0.869	-
Log-likelihood	2403		2403	3344

NOTES: Marginal effects at the means are entered only for variables which do not enter the model in a simple linear and additively separable form (so that their marginal effect is identical with their fitted coefficient). The option for errors clustered on counties is not offered in our SARAR(1,1) estimation algorithm, so we provide the non-clustered OLS estimates for comparison to the SARAR(1,1) results. Implied marginals at the means for the SARAR(1,1) specifications cannot be calculated trivially using the "margins" command in Stata 12. Political parties for gubernatorial vote shares in the November 2010 election are sorted according to left-leaning and then right-leaning platforms and within these two groups by mainstream and then fringe groups. Democrats are listed first because the democratic candidate prevailed in this election. Among the ecological regions, we found no statistically significant differences among the following omitted categories: Northern Basin and Range, Arizona/New Mexico Plateau, Mojave Basin and Range, CA Coast. Sage/Chaparral/Oak, S. & Baja CA Pine-Oak Mtns, Klamath Mountains, and Coast Range.

TABLE 8. Holdout Samples

County	Population	# Tracts	Actual	Fitted Share Yes		In 99% Interval?
			Share Yes	Point	95% Interval	
Alameda	1,457,095	313	0.564	0.556	(0.544, 0.567)	✓
Alpine	1,153	1	0.437	0.493	(0.476, 0.511)	
Amador	38,039	7	0.335	0.373	(0.356, 0.389)	
Butte	217,917	41	0.372	0.396	(0.381, 0.411)	
Calaveras	46,548	7	0.368	0.371	(0.353, 0.387)	✓
Colusa	21,001	5	0.253	0.276	(0.256, 0.299)	✓
Contra Costa	1,015,571	164	0.467	0.489	(0.478, 0.501)	
Del Norte	28,729	6	0.402	0.396	(0.378, 0.413)	✓
El Dorado	175,941	34	0.407	0.393	(0.369, 0.417)	✓
Fresno	890,750	155	0.31	0.321	(0.309, 0.332)	✓
Glenn	27,891	5	0.279	0.315	(0.292, 0.338)	
Humboldt	129,003	26	0.48	0.521	(0.496, 0.545)	
Imperial	160,034	26	0.319	0.348	(0.325, 0.372)	
Inyo	17,438	6	0.3	0.295	(0.275, 0.315)	✓
Kern	775,555	134	0.274	0.283	(0.273, 0.293)	✓
Kings	146,696	24	0.365	0.347	(0.331, 0.364)	✓
Lake	64,756	12	0.391	0.415	(0.401, 0.428)	
Lassen	34,428	7	0.316	0.297	(0.274, 0.323)	✓
Los Angeles	9,785,295	1963	0.427	0.434	(0.426, 0.441)	✓
Madera	144,794	19	0.335	0.312	(0.301, 0.324)	✓
Marin	246,711	49	0.593	0.575	(0.560, 0.591)	✓
Mariposa	17,865	4	0.53	0.512	(0.494, 0.531)	✓
Mendocino	86,030	18	0.515	0.524	(0.503, 0.545)	✓
Merced	242,235	46	0.305	0.307	(0.297, 0.316)	✓
Modoc	9,162	4	0.252	0.28	(0.234, 0.326)	✓
Mono	12,925	2	0.425	0.437	(0.406, 0.468)	✓
Monterey	404,922	78	0.55	0.494	(0.469, 0.517)	✓
Napa	132,173	25	0.451	0.482	(0.467, 0.496)	
Nevada	97,063	18	0.459	0.461	(0.446, 0.476)	✓
Orange	2,976,831	565	0.349	0.347	(0.340, 0.355)	✓
Placer	332,059	49	0.41	0.368	(0.356, 0.380)	✓
Plumas	20,550	5	0.333	0.344	(0.318, 0.372)	✓
Riverside	2,036,304	336	0.341	0.338	(0.331, 0.346)	✓
Sacramento	1,375,605	269	0.463	0.446	(0.437, 0.456)	✓
San Benito	54,752	8	0.457	0.398	(0.379, 0.415)	✓
San Bernardino	1,986,635	236	0.331	0.335	(0.330, 0.339)	✓
San Diego	2,987,543	581	0.395	0.4	(0.394, 0.407)	✓
San Francisco	797,271	156	0.603	0.616	(0.605, 0.626)	✓
San Joaquin	664,641	120	0.363	0.348	(0.339, 0.357)	✓
San Luis Obispo	262,149	41	0.438	0.421	(0.407, 0.435)	✓
San Mateo	701,886	151	0.536	0.54	(0.529, 0.551)	✓
Santa Barbara	402,025	82	0.466	0.435	(0.418, 0.452)	✓
Santa Clara	1,729,378	331	0.532	0.517	(0.505, 0.529)	✓
Santa Cruz	251,398	52	0.599	0.564	(0.544, 0.584)	✓
Shasta	179,387	33	0.378	0.408	(0.390, 0.428)	
Sierra	3,240	1	0.389	0.355	(0.328, 0.384)	✓

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Table 8. – continued from previous page

County	Population	# Tracts	Actual	Fitted Share Yes		In 99% Interval?
			Share Yes	Point	95% Interval	
Siskiyou	44,404	14	0.539	0.451	(0.409, 0.492)	✓
Solano	406,461	78	0.429	0.425	(0.413, 0.437)	✓
Sonoma	464,218	86	0.574	0.54	(0.521, 0.558)	✓
Stanislaus	505,165	89	0.336	0.342	(0.334, 0.349)	✓
Sutter	90,731	18	0.309	0.319	(0.306, 0.333)	✓
Tehama	60,601	11	0.392	0.401	(0.375, 0.425)	✓
Trinity	13,922	4	0.319	0.34	(0.313, 0.366)	✓
Tulare	416,299	75	0.248	0.274	(0.258, 0.290)	
Tuolumne	55,761	10	0.373	0.391	(0.378, 0.405)	
Ventura	792,313	148	0.421	0.403	(0.392, 0.415)	✓
Yolo	192,974	36	0.53	0.507	(0.495, 0.520)	✓
Yuba	70,906	11	0.496	0.434	(0.416, 0.450)	✓

NOTES: For each county, we use that county as a hold-out sample of Census tracts and fit the model in Table 2 based on tracts in the remaining counties. Based on these parameters, we predict the proportion of votes in favor of Prop 21 for each of the tracts in the hold-out county. Counts of tracts may fall short of the total in some counties because of missing data in our estimating sample.

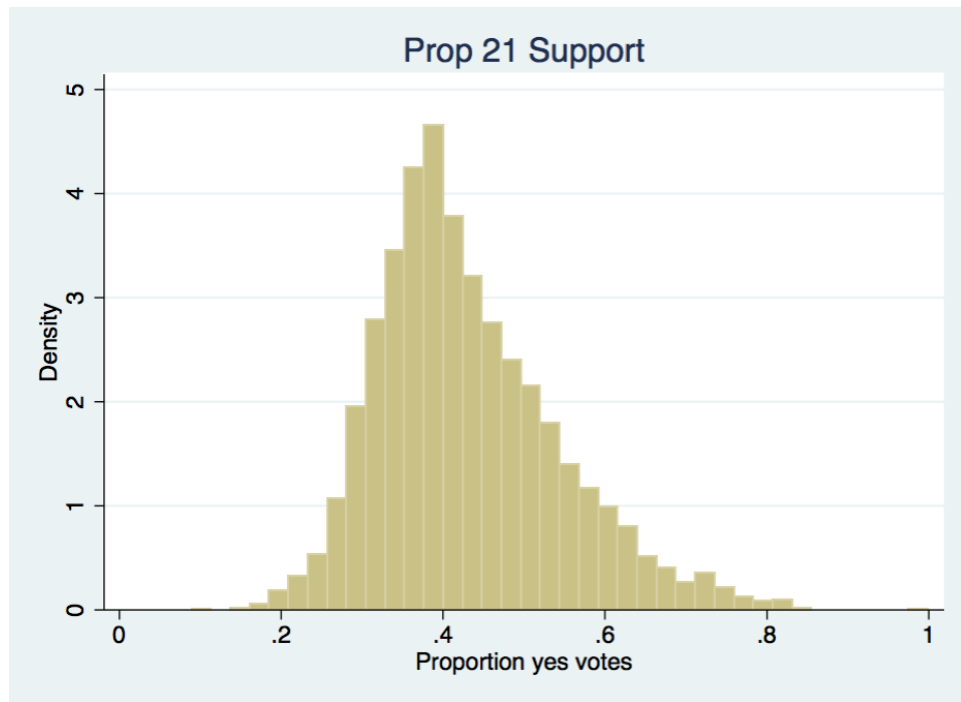


FIGURE 1. Differential support for Prop 21

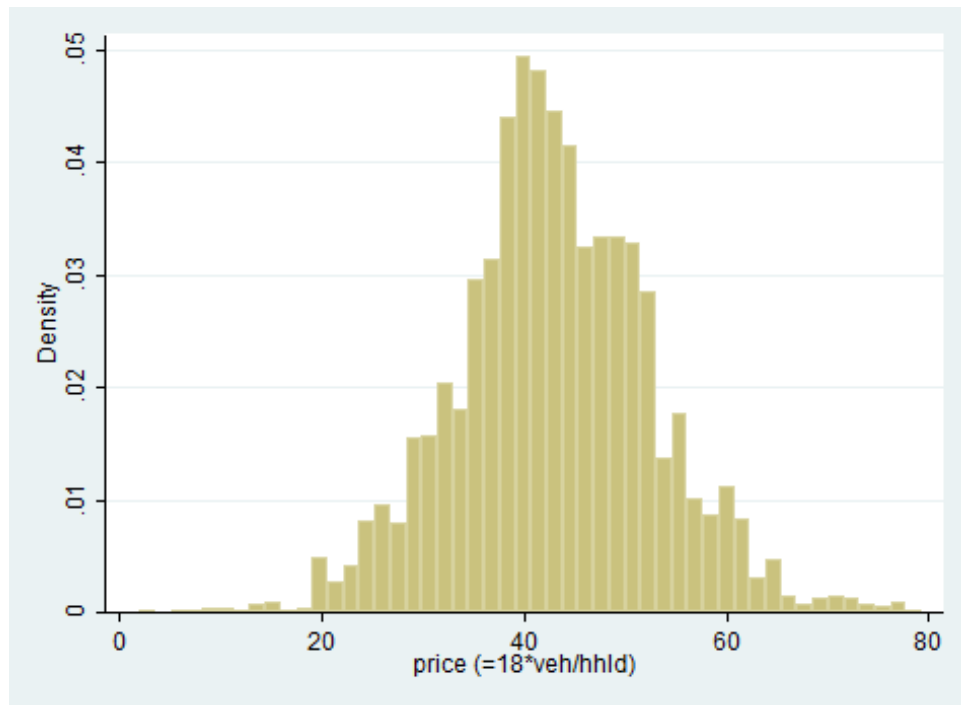


FIGURE 2. Annual cost of Prop 21 per household



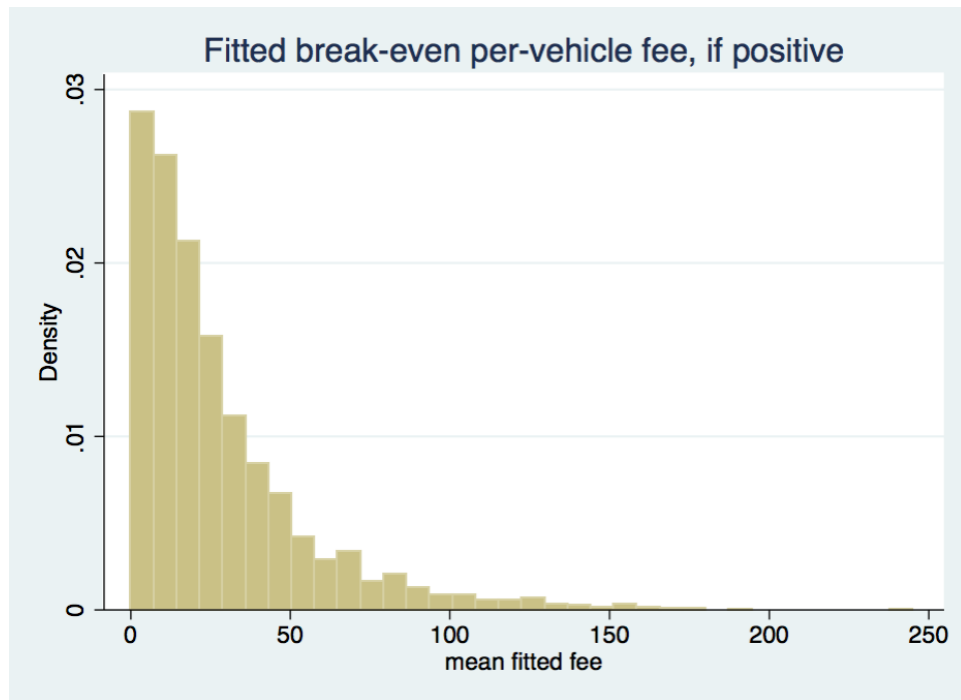


FIGURE 3. Tract level break-even fees

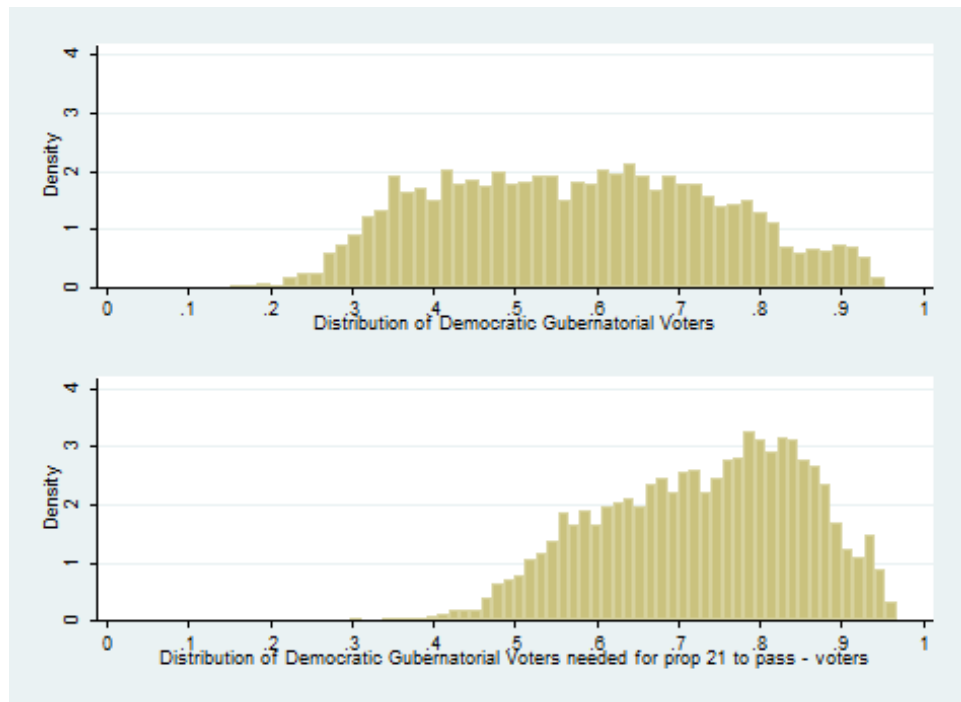


FIGURE 4. Political shift needed to pass Prop 21, holding constant population that voted

# APPENDIX C

## CHAPTER IV TABLES AND FIGURES

TABLE 9. Descriptive Statistics – California (N=9,044)

VARIABLES	(1) Full sample	(2) Stay	(3) Move	(4) Close
0 = stat quo; 1=move; 2=out of biz	0.0818 (0.390)	0 (0)	1 (0)	2 (0)
annual firm sales	15.25 (22.54)	15.28 (22.50)	19.25 (28.61)	13.81 (22.55)
Estab Empl at Loc (repl on move)	3.968 (5.539)	3.974 (5.471)	5.002 (8.196)	3.670 (6.675)
tract hhld income	7.184 (3.555)	7.202 (3.564)	7.174 (3.506)	6.737 (3.317)
tract % Hispanic	0.254 (0.217)	0.254 (0.217)	0.248 (0.215)	0.266 (0.221)
tract % Black	0.0623 (0.111)	0.0621 (0.111)	0.0615 (0.106)	0.0679 (0.119)
tract % Asian/other	0.274 (0.171)	0.273 (0.170)	0.296 (0.186)	0.287 (0.174)
ever regulated? (PCE/HC)	-	-	-	-
... x Korean-owned	-	-	-	-
% chng, county qtr1 payroll	0.0462 (0.0666)	0.0458 (0.0668)	0.0479 (0.0570)	0.0561 (0.0602)
% chng, county establish.	0.00828 (0.0166)	0.00814 (0.0167)	0.0105 (0.0151)	0.0113 (0.0149)
% chng, county employment	0.00744 (0.0367)	0.00714 (0.0368)	0.0104 (0.0308)	0.0147 (0.0328)
Observations	9,044	4,974	458	3,612

TABLE 10. Descriptive Statistics - SCAQMD (N=4,874)

VARIABLES	(1) Full sample	(2) Stay	(3) Move	(4) Close
0 = stat quo; 1=move; 2=out of biz	0.0770 (0.379)	0 (0)	1 (0)	2 (0)
annual firm sales	15.38 (25.62)	15.41 (25.57)	21.42 (34.72)	13.81 (25.38)
Estab Empl at Loc (repl on move)	3.942 (5.980)	3.951 (5.932)	5.397 (9.912)	3.537 (6.531)
tract hhld income	7.088 (3.566)	7.106 (3.576)	7.134 (3.418)	6.593 (3.263)
tract % Hispanic	0.301 (0.237)	0.300 (0.237)	0.301 (0.248)	0.318 (0.239)
tract % Black	0.0681 (0.127)	0.0680 (0.127)	0.0615 (0.113)	0.0722 (0.129)
tract % Asian/other	0.293 (0.173)	0.292 (0.173)	0.310 (0.184)	0.312 (0.174)
ever regulated? (PCE/HC)	0.436 (0.496)	0.447 (0.497)	0.342 (0.475)	0.158 (0.365)
... x Korean-owned	0.217 (0.412)	0.223 (0.416)	0.179 (0.385)	0.0625 (0.242)
% chng, county qtr1 payroll	0.0399 (0.0498)	0.0395 (0.0500)	0.0407 (0.0401)	0.0492 (0.0426)
% chng, county establish.	0.00958 (0.0161)	0.00943 (0.0162)	0.0118 (0.0137)	0.0133 (0.0137)
% chng, county employment	0.00533 (0.0313)	0.00508 (0.0314)	0.00596 (0.0247)	0.0120 (0.0269)
Observations	4,874	2,784	234	1,856

TABLE 11. Descriptive Statistics - not SCAQMD (N=4,170)

VARIABLES	(1) Full sample	(2) Stay	(3) Move	(4) Close
0 = stat quo; 1=move; 2=out of biz	0.0876 (0.403)	0 (0)	1 (0)	2 (0)
annual firm sales	15.08 (18.15)	15.12 (18.10)	16.99 (20.18)	13.80 (19.11)
Estab Empl at Loc (repl on move)	3.998 (4.956)	4.003 (4.854)	4.589 (5.888)	3.811 (6.822)
tract hhld income	7.300 (3.539)	7.319 (3.545)	7.215 (3.602)	6.889 (3.367)
tract % Hispanic	0.198 (0.175)	0.197 (0.174)	0.193 (0.157)	0.211 (0.185)
tract % Black	0.0554 (0.0879)	0.0550 (0.0870)	0.0614 (0.0973)	0.0634 (0.106)
tract % Asian/other	0.251 (0.164)	0.251 (0.164)	0.281 (0.186)	0.261 (0.169)
ever regulated? (PCE/HC)	-	-	-	-
... x Korean-owned	-	-	-	-
% chng, county qtr1 payroll	0.0539 (0.0817)	0.0535 (0.0820)	0.0553 (0.0698)	0.0634 (0.0737)
% chng, county establish.	0.00670 (0.0171)	0.00658 (0.0172)	0.00911 (0.0163)	0.00914 (0.0157)
% chng, county employment	0.00998 (0.0422)	0.00963 (0.0423)	0.0150 (0.0355)	0.0175 (0.0378)
Observations	4,170	2,190	224	1,756

TABLE 12. Binomial Logit Models

Variable	(1)	(2)	(3)
1(SCAQMD)	0.077 (0.343)	0.0684 (0.304)	0.0567 (0.251)
1(SCAQMD) $\times$ 1990(base year)	0	0	0
1(SCAQMD) $\times$ 1991	0.0441 (0.156)	0.0507 (0.179)	0.0442 (0.156)
1(SCAQMD) $\times$ 1992	-0.0398 (-0.134)	-0.0583 (-0.197)	-0.0612 (-0.206)
1(SCAQMD) $\times$ 1993	-0.123 (-0.421)	-0.136 (-0.465)	-0.142 (-0.485)
1(SCAQMD) $\times$ 1994	-0.288 (-0.907)	-0.272 (-0.856)	-0.287 (-0.902)
1(SCAQMD) $\times$ 1995	-0.226 (-0.842)	-0.224 (-0.833)	-0.241 (-0.897)
1(SCAQMD) $\times$ 1996	-0.504* (-1.933)	-0.485* (-1.859)	-0.499* (-1.912)
1(SCAQMD) $\times$ 1997	-0.0736 (-0.288)	-0.0835 (-0.327)	-0.103 (-0.403)
1(SCAQMD) $\times$ 1998	-0.354 (-1.369)	-0.366 (-1.415)	-0.389 (-1.504)
1(SCAQMD) $\times$ 1999	-0.133 (-0.521)	-0.151 (-0.584)	-0.181 (-0.703)
1(SCAQMD) $\times$ 2000	-0.0754 (-0.285)	-0.146 (-0.541)	-0.18 (-0.670)
1(SCAQMD) $\times$ 2001	-0.251 (-0.961)	-0.236 (-0.894)	-0.274 (-1.041)
1(SCAQMD) $\times$ 2002	-0.25 (-0.954)	-0.2 (-0.752)	-0.244 (-0.917)
1(SCAQMD) $\times$ 2003	-0.13 (-0.480)	-0.0886 (-0.322)	-0.134 (-0.488)
1(SCAQMD) $\times$ 2004	-0.183 (-0.706)	-0.177 (-0.676)	-0.219 (-0.839)
1(SCAQMD) $\times$ 2005	-0.244 (-0.958)	-0.192 (-0.743)	-0.236 (-0.911)
1(SCAQMD) $\times$ 2006	-0.115 (-0.416)	-0.0981 (-0.354)	-0.135 (-0.486)
1(SCAQMD) $\times$ 2007	-0.24 (-0.866)	-0.202 (-0.726)	-0.239 (-0.858)
1(SCAQMD) $\times$ 2008	-0.570** (-2.087)	-0.569** (-2.081)	-0.604** (-2.208)
% chng, county qtr1 payroll		-1.174** (-1.973)	-1.207** (-2.002)
% chng, county establish.		-1.927 (-0.946)	-1.049 (-0.508)
% chng, county employment		2.056** (2.301)	2.043** (2.272)
Annual firm sales			-0.00385 (-1.398)
# employees (firm)			-0.000485 (-0.0440)
Tract hhld income			-0.0179** (-2.328)
Tract % Hispanic			0.0561 (0.495)
Tract % Black			0.278* (1.668)
Tract % Asian/other			0.504*** (3.885)
Constant	-3.670*** (-22.04)	-3.613*** (-21.01)	-3.615*** (-19.64)
Observations	88,504	88,504	88,504
Errors clustered on	DUNS #	DUNS #	DUNS #
Robust z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1			

TABLE 13. Binomial Logit Model - Treated/Not Treated

Variable	(1)	(2)	(3)	Margins Not SC	Margins SC
Treated	-0.215*** (-4.791)	-0.220*** (-4.197)	-0.250*** (-6.967)		
1(SCAQMD)	-0.0816* (-1.709)	-0.0940** (-2.299)	-0.103 (-0.420)	-0.00539*** (-2.641)	-0.00539*** (-2.641)
% chng, county qtr1 payroll		-1.008** (-2.307)	-1.071** (-2.335)		
% chng, county establish.		4.929** (1.993)	5.220** (2.112)		
% chng, county employment		2.432*** (2.871)	2.551*** (2.827)		
Tract % Hispanic			0.301 (1.616)	0.0126 (1.574)	-0.00418 (-0.931)
1(SCAQMD)×Tract % Hispanic			-0.413* (-1.857)		
Tract % Black			0.719*** (3.156)	0.0302*** (3.407)	0.00859*** (6.789)
1(SCAQMD)×Tract % Black			-0.488** (-2.208)		
Tract % Asian/other			0.400** (2.453)	0.0168** (2.561)	0.0345*** (6.631)
1(SCAQMD)×Tract % Asian/other			0.529** (2.394)		
Tract hhld income			-0.00339 (-0.367)	-0.000142 (-0.364)	-0.000353 (-0.433)
1(SCAQMD)×c.hhinc_mean			-0.00613 (-0.233)		
Annual firm sales			-0.0026 (-1.077)		
# employees (firm)			-0.00522 (-0.385)		
Constant	-3.063*** (-71.40)	-3.085*** (-92.95)	-3.206*** (-24.44)		
Observations	88,504	88,504	88,504	88,504	88,504
Errors clustered on	County	County	County	County	County

Robust z-statistics in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

TABLE 14. Pollution Concentrations

Evolution of PCE across monitors and over time (log-linear)				
Variable	(1) log(avg)	(2) log(median)	(3) log(90th %ile)	(4) log(75th %ile)
1(SCAQMD)	48.78** (2.25)	52.47*** (2.67)	56.32** (2.40)	52.94*** (2.61)
year	-0.116*** (-18.15)	-0.117*** (-23.21)	-0.120*** (-20.94)	-0.120*** (-23.92)
1(SCAQMD)×year	-0.0239** (-2.21)	-0.0257*** (-2.63)	-0.0277** (-2.36)	-0.0260** (-2.56)
Constant	229.9*** (17.95)	231.3*** (22.88)	237.2*** (20.75)	237.7*** (23.64)
Observations	220	219	219	219
R-squared	0.800	0.823	0.801	0.837

Robust t-statistics in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1



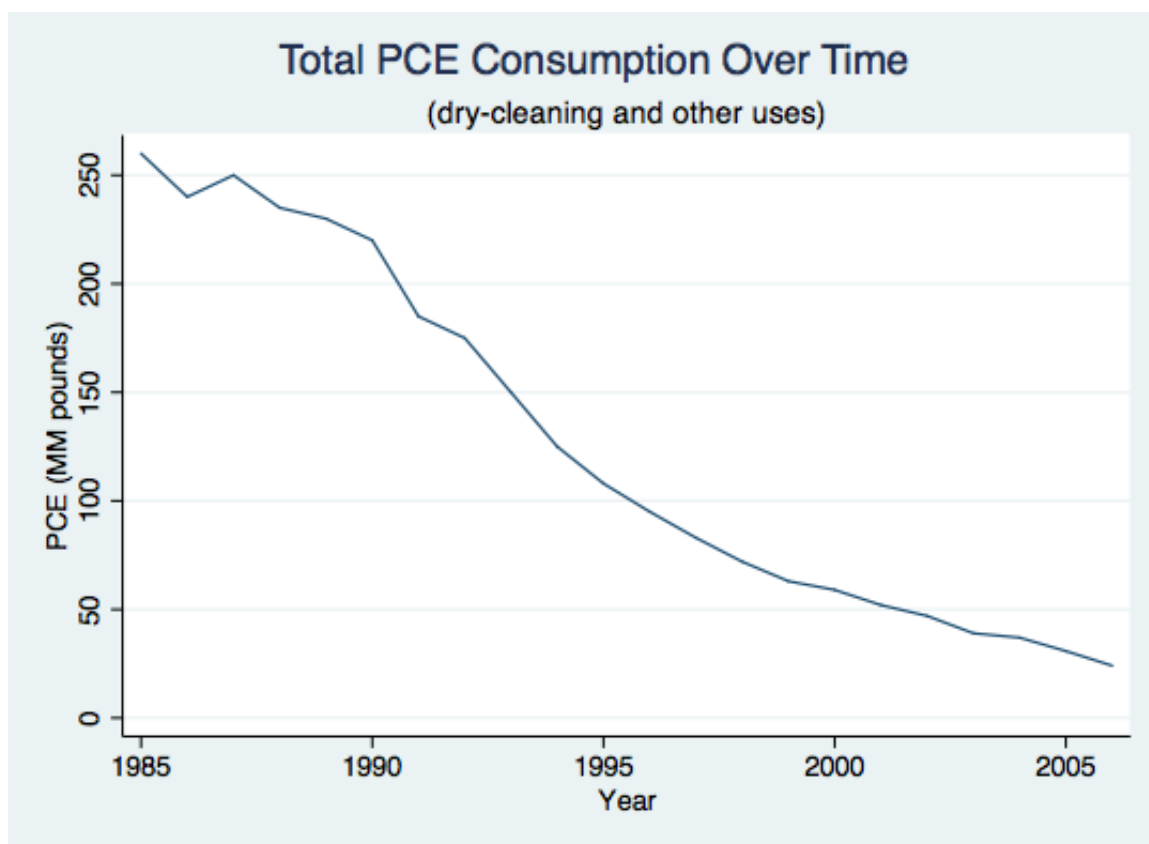


FIGURE 5. Total PCE Consumption Over Time. Source:  
<http://www.epa.gov/dfe/pubs/projects/garment/graph1.htm>

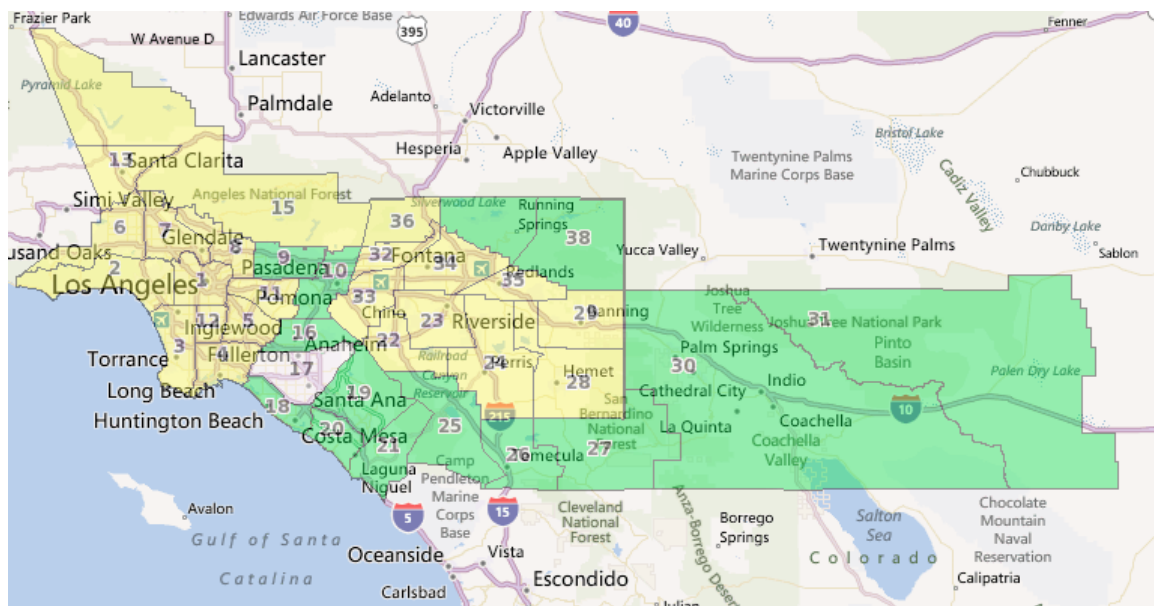


FIGURE 6. Map of South Coast Air Quality Management District Jurisdiction

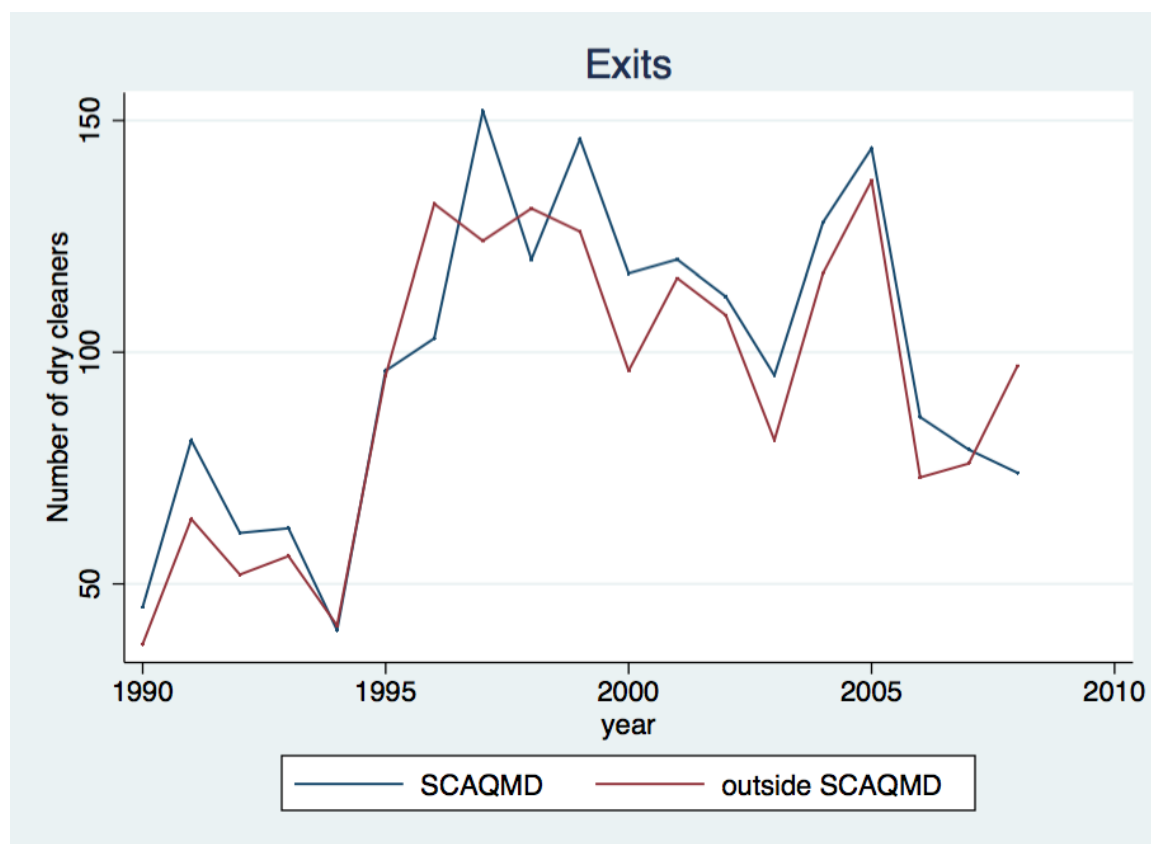


FIGURE 7. Instances of dry cleaners closing or changing owners

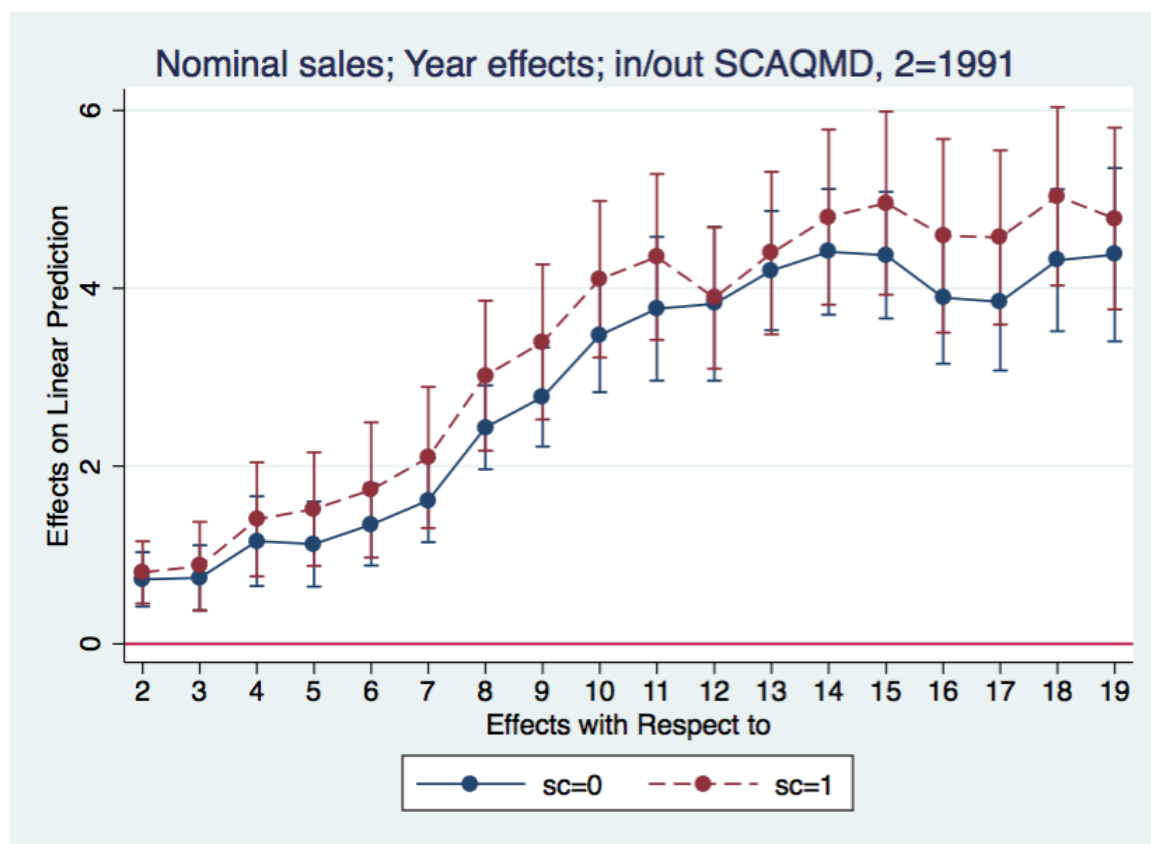


FIGURE 8. Sales levels by year

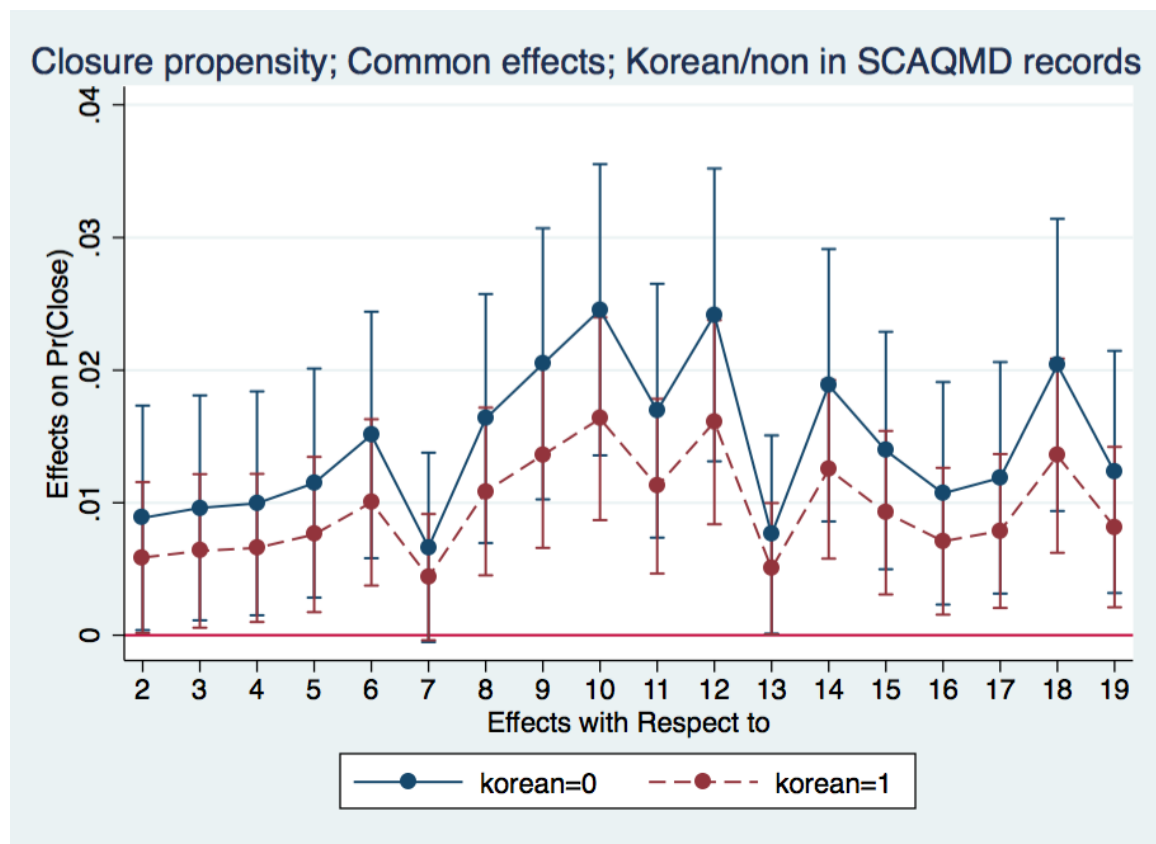


FIGURE 9. Effect of Korean Ownership on Exits by Year

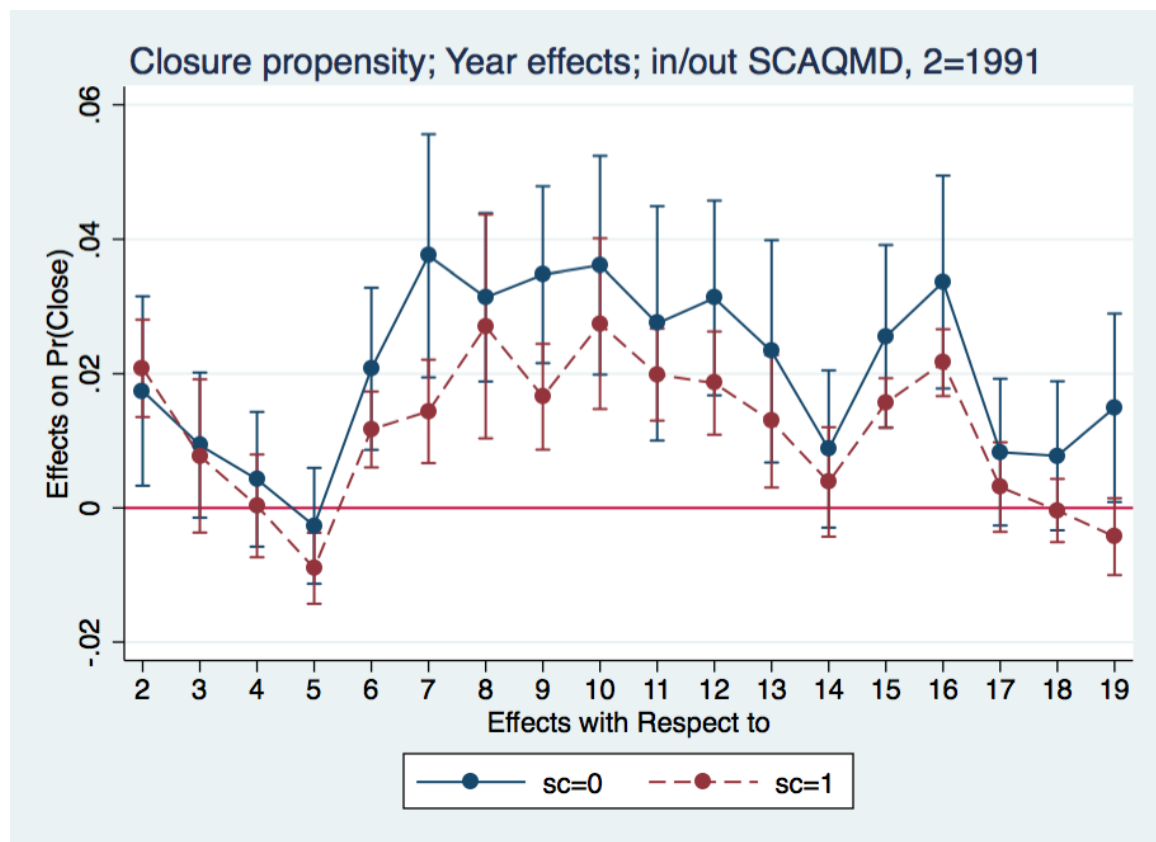


FIGURE 10. Exit propensities by year

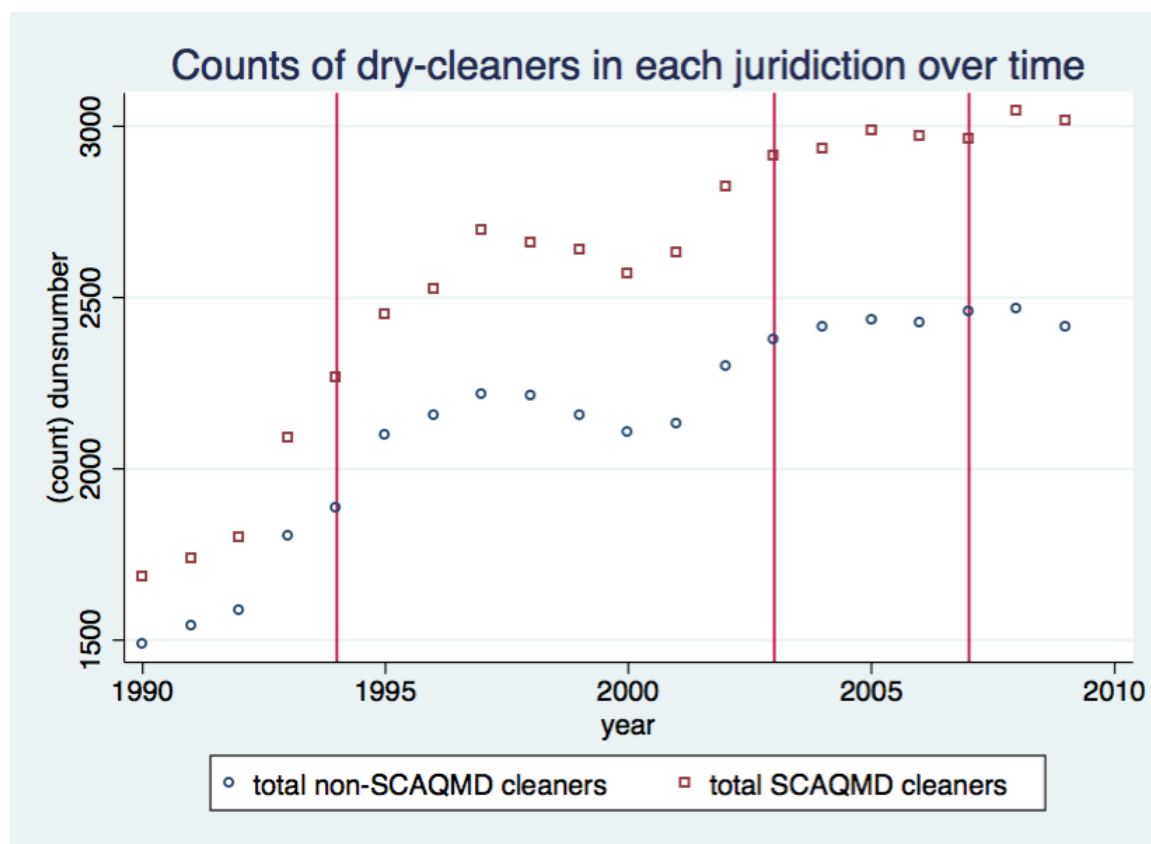


FIGURE 11. Counts of cleaners

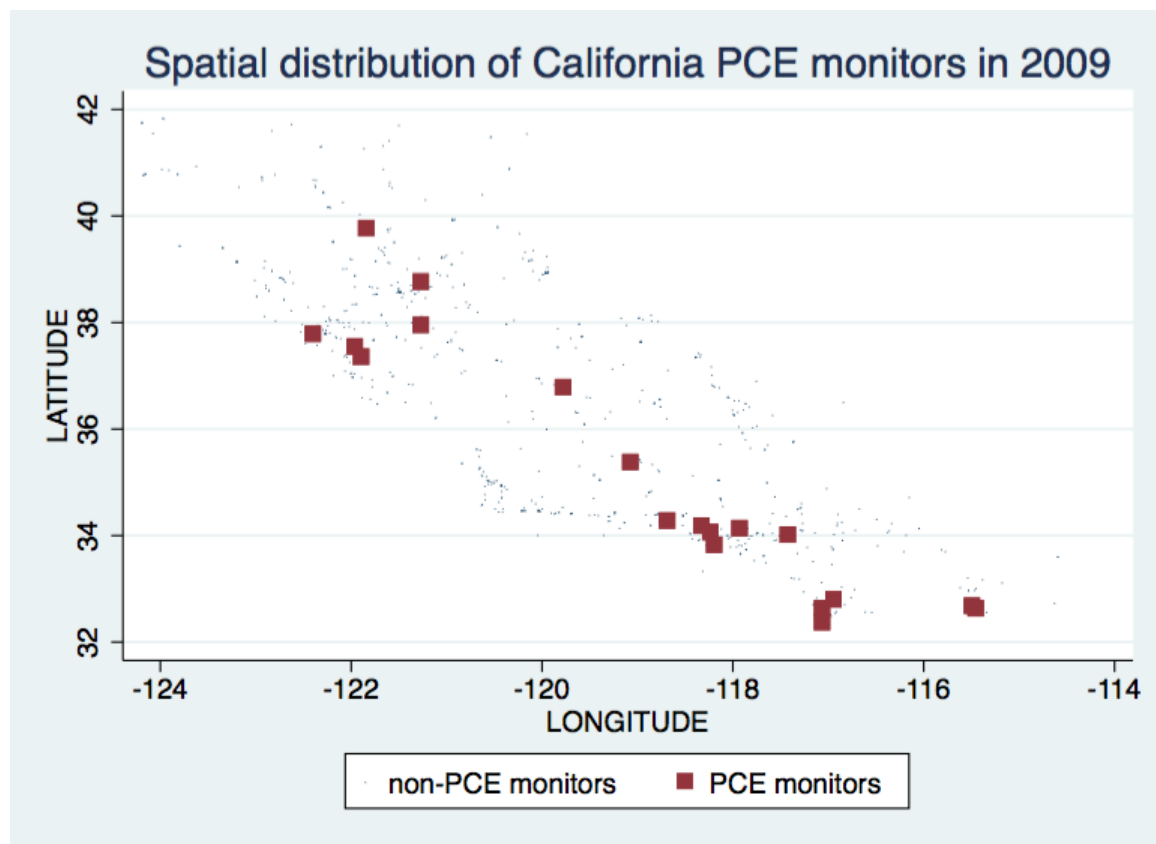


FIGURE 12. Locations of Monitors



Freq.	Percent	Cum.	Pattern
11	35.48	35.48	11111111111111111111
2	6.45	41.94	.....11111111111111
2	6.45	48.39	11111111.....
2	6.45	54.84	1111111111.....
1	3.23	58.06	.....11111111
1	3.23	61.29	.....111111111111
1	3.23	64.52	.....11.....
1	3.23	67.74	.....111.....
1	3.23	70.97	.....1111111111111111
1	3.23	74.19	....111111111111111111
1	3.23	77.42	...111111111111111111
1	3.23	80.65	..11111111111111111111
1	3.23	83.87	1.....
1	3.23	87.10	111.....
1	3.23	90.32	1111.....
1	3.23	93.55	11111.....
1	3.23	96.77	1111111111.....
1	3.23	100.00	111111111111.....
31	100.00		XXXXXXXXXXXXXXXXXXXXX

FIGURE 13. Panel Structure

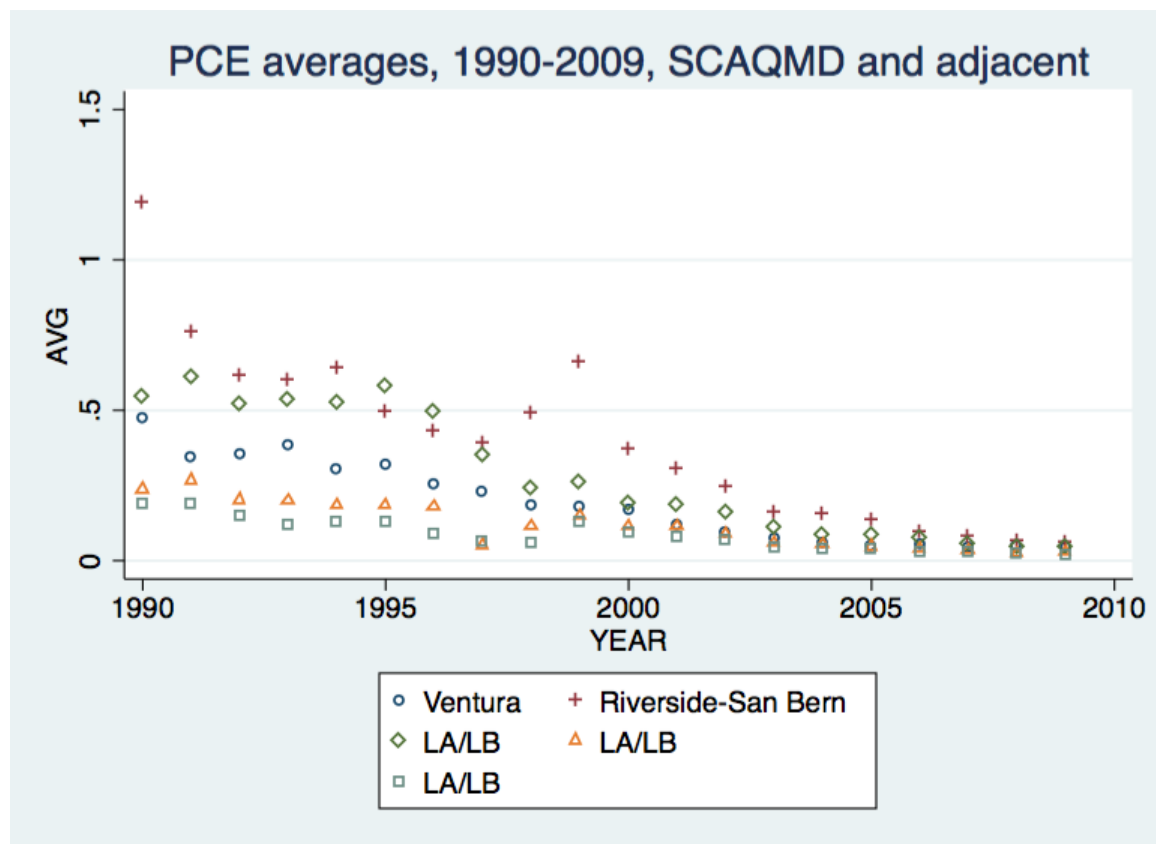


FIGURE 14. PCE Averages (1990-2009) - SCAQMD

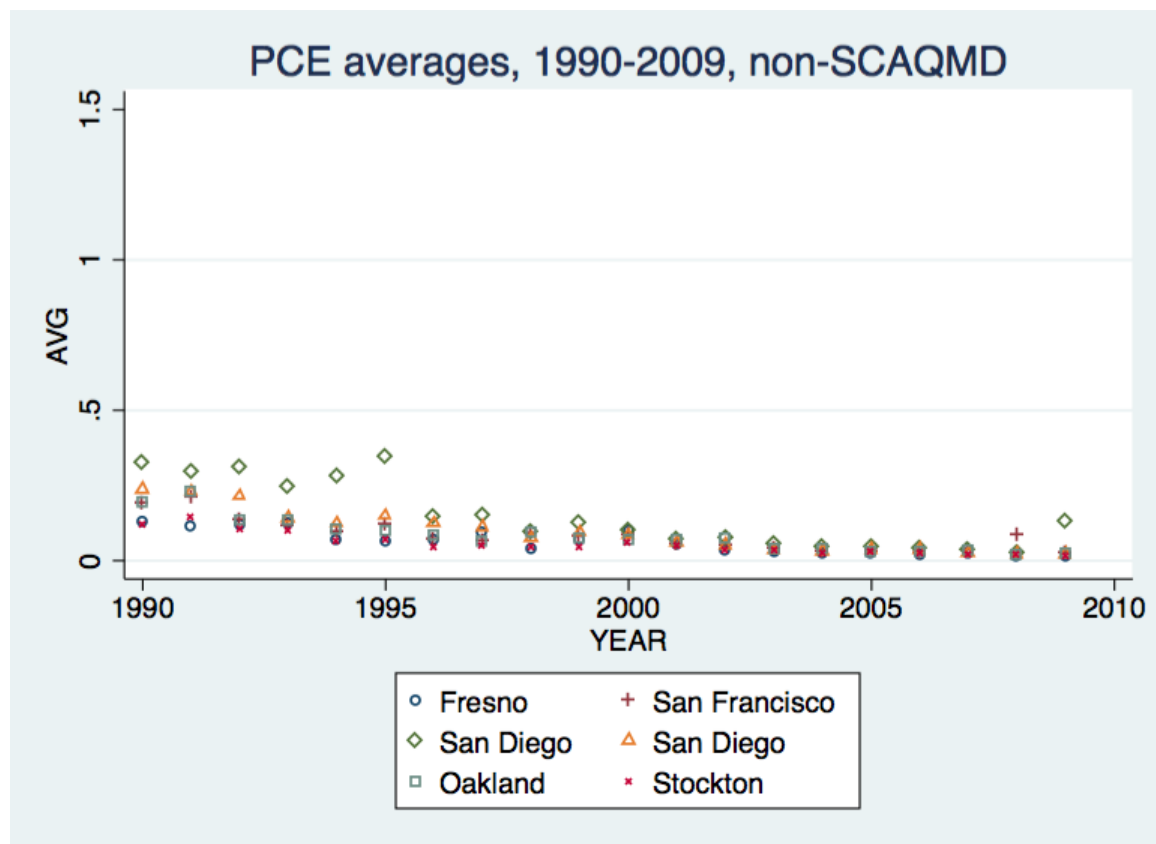


FIGURE 15. PCE Averages (1990-2009) - Outside SCAQMD

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